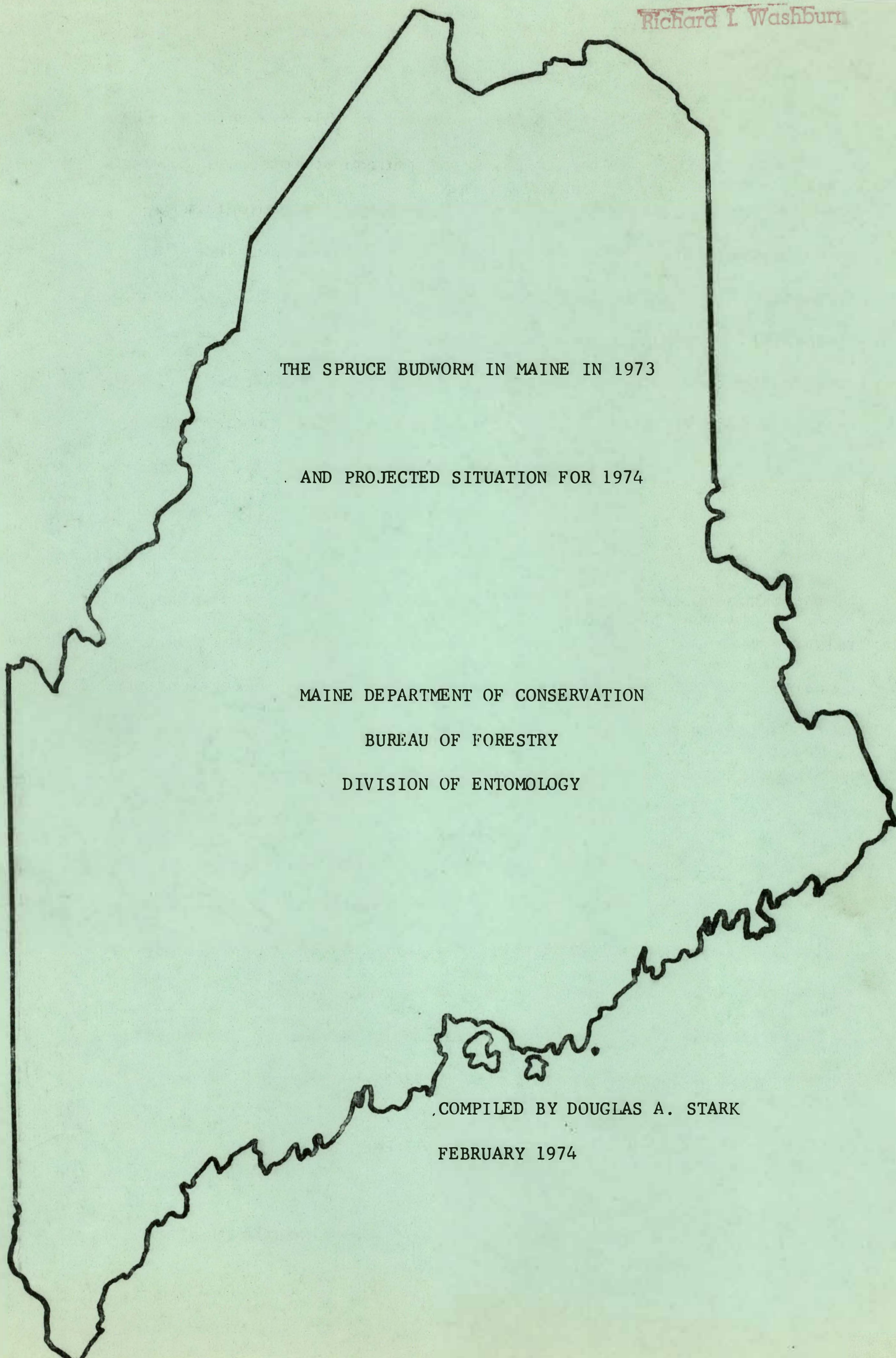

THE SPRUCE BUDWORM IN MAINE IN 1973

AND PROJECTED SITUATION FOR 1974

MAINE DEPARTMENT OF CONSERVATION

BUREAU OF FORESTRY

DIVISION OF ENTOMOLOGY

COMPILED BY DOUGLAS A. STARK

FEBRUARY 1974

ACKNOWLEDGEMENT

This is the first spruce budworm report of this type written under the 4-Region reorganizational plan of the Bureau of Forestry. Regional spruce budworm reports were submitted by Regional Entomologists and consolidated in this statewide report. Acknowledgement is therefore extended to R. W. Nash, State Entomologist, who provided the accounts of the 1973 spray operation and research, and to John Chadwick for spray plane calibration data; to Regional Entomologists David Struble, Hubbard Trefts, and Henry Trial, Jr. for their reports, and to George LaBonte for technical assistance and training at the Portage field laboratory; to Insect Rangers for field survey data, and to girls at the Portage and Cross Lake field laboratories for laboratory data used in this report; to the Entomology Division staff in Augusta for Forest Insect Survey data relating to the spruce budworm; to Fire Control Division and Industry - supplied personnel who assisted in making field survey collections; to Dr. A. E. Brower for his monitoring of the biota in the operational and experimental spray blocks; and to Vaughn McCowan, Entomologist, and other U. S. Forest Service personnel for experimental spray plot data.

This is the first year we have used the Canadian sampling systems in our budworm surveys. We hereby extend our appreciation to our Canadian friends, particularly to Ed Kettela, Maritimes Forest Research Centre, Fredericton, N.B., for helping us implement these surveys.

Appreciation is also extended to Dr. Gary Simmons, U. of M., Orono for his guidance in our changeover in sampling methods during the 1973 survey season and assistance with the statistical analysis of efficacy and other spray data.

Douglas A. Stark

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INTRODUCTION

The spruce budworm has been increasing in intensity in recent years in areas well-removed from the Cross Lake-Madawaska Lake-Portage-Squapan Lake and Oxbow areas in northeastern Maine previously treated by spraying in one year or another since 1954. Budworm in adjacent Canadian provinces likewise has increased in intensity over 1972 conditions.

Following the 1972 egg mass and ground and aerial defoliation surveys in Maine, all the data were discussed in detail at joint meetings of our staff with representatives of the U. S. Forest Service, land managers, and representatives of Forest Protection Ltd. of New Brunswick, Canada on October 17 and 18, 1972. These meetings resulted in the recommendation to treat 450,000 acres operationally in 1973 with the insecticide Zectran. Some of this acreage involved entirely new areas never before sprayed, i.e. the St. Francis and Telos Lake areas.

In addition to the operational spray project, there were three types of experimental spray application: 1. Areas sprayed experimentally but operationally with Zectran at less gallonage per acre and different timing than in the over-all project, 2. with Bacillus thuringiensis, and 3. small blocks treated by helicopter with Fenitrothion or Zectran. Over-all therefore, treatments were made on 470,000 acres with Zectran.

1973 SPRAY OPERATION AND RESEARCH

The first part of this section concerns the operational project. The research-experimental phases follow.

The 1973 protection project consisted of 5 operational spray areas (Fig. 1) and involved the usual preparations and detailed planning. Clearance was obtained first with the Board of Pesticides Control. Open explanatory meetings were held with conservation groups, related State agencies, and local groups. The brochure with colored illustrations originally issued as Circular No. 11, January 1972, was revised in January 1973. Publicity was released through the news media, and included several TV programs.

Contact Work

The first spring field activity associated with the spray project was the contact work or public relations phase. Most of the contact work was concentrated in spray areas 1, 3 and 5 (Fig. 1) in Aroostook Co. Personal contacts beginning in February were made with all residents in or within 1/4 mile of spray areas to explain the project, procedures to be used, and to seek out caution and voidance areas. A notice was left in the event no one was at home.

All camps within and adjacent to the proposed spray areas were also visited by Forestry personnel familiar with these areas. Remote areas impossible to reach by car or truck were reached by snowmobile. A notice of the proposed spray project and a fact sheet about the insecticide "Zectran" were posted conspicuously on each camp. Also contacted were non-resident owners, Town officials and public lot lessees. Telephone numbers and addresses of people to contact (Locke and Struble) for further information concerning the project were also left with the notices.

Caution areas sought were small fish ponds, bee-hives, poultry and mink farms, organic gardens, and other areas which residents did not want sprayed. These were detailed on USGS maps used by spray and guide plane pilots, and on the master map at the airport, and were eliminated from the spray plan. Areas of high risk to planes, such as radio and TV towers, were also mapped. In late May, caution-area markers, each consisting of a brush-filled cloth bag covered with a fluorescent orange hunting vest attached at the end of a long pole, were secured to a dominant tree or structure near the hazard area so that it extended above the forest canopy. This difficult task was accomplished with the helpful assistance of Maine Public Service Co. personnel and equipment through Don Collins in Presque Isle.

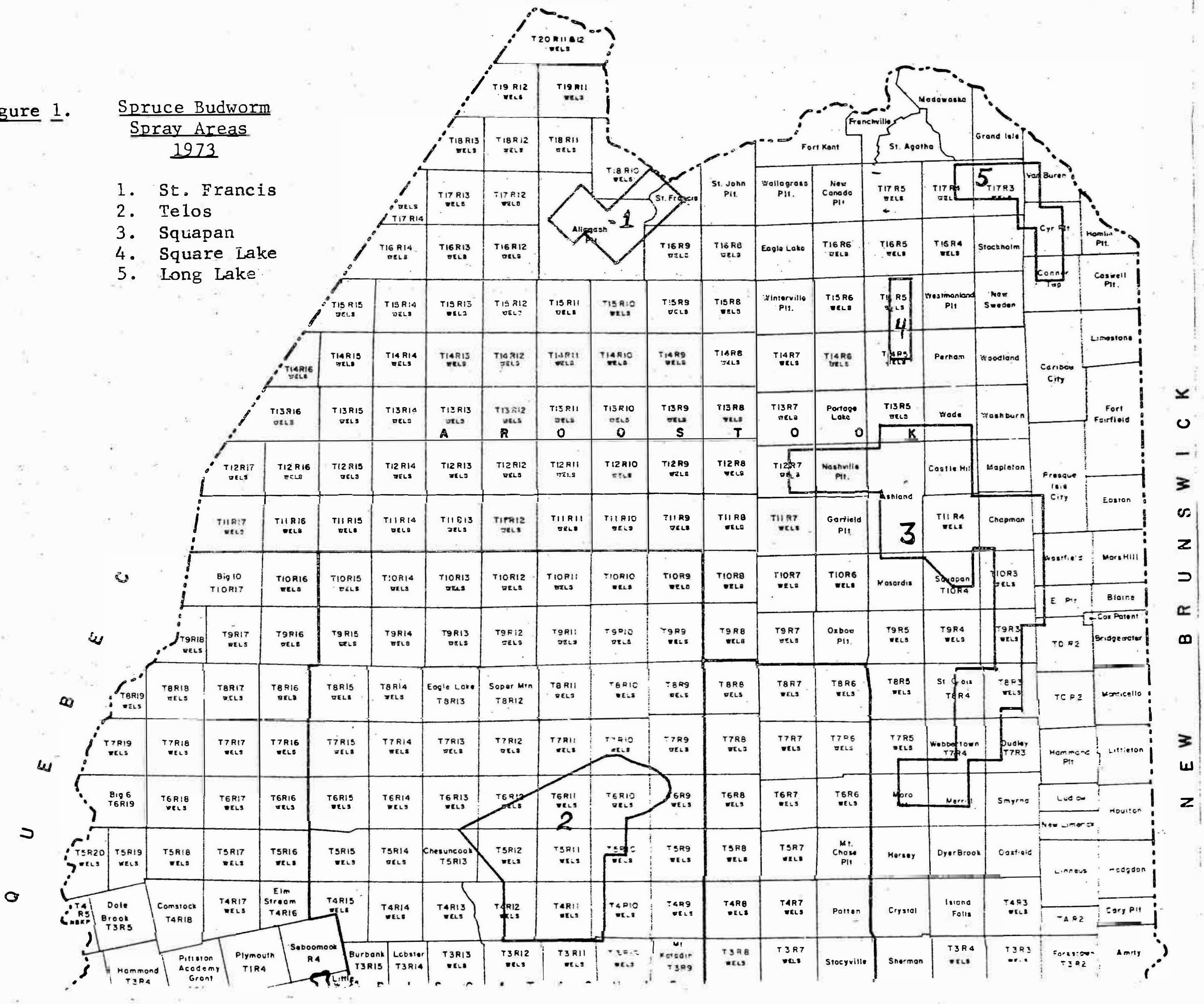
Funding and Cost

State of Maine funds were made available May 8 through legislative action. Equal U.S. Forest Service funds were made available upon approval of the Environmental Impact Statement by the Federal Environmental Protection Agency.

Funding of previous projects had been three-way but progressed over the years from 25% Federal to essentially one-third each - federal, private, State.

Figure 1. Spruce Budworm Spray Areas 1973

1. St. Francis
2. Telos
3. Squapan
4. Square Lake
5. Long Lake



In those years the Maine Forestry District tax system readily enabled the Legislature to provide funds directly from owners in unorganized townships. In the period July 1, 1972 to 1973 there was a gradual changeover to taxation based upon Tree Growth or Productivity, so planned that the State General Fund would provide for such items as fire and budworm suppression. Thus, 1973 funds for the project were equal State and Federal.

Actual cost of the 1973 operation was $2.71 per acre of which $2.61 was direct cost.

The Operational Project

Presque Isle Airport was chosen as the best base of operations. For the remote areas (Telos and St. Francis), detailed consideration was given to use of helicopters or the Millinocket Airport; however, these alternative were abandoned due to associated administrative, transportation and housing problems.

Planning and efficiency were aided greatly by the cooperation of numerous State and City departments, named in previous biennial reports. The greatest benefit was by the Department of Education through the Northern Maine Vocational Technical Institute where the complete spray crew ate (at cost) in the dining hall and lived gratis in the dormitories. This was of vast benefit in having all personnel together on call and having all associated functions and supervision at one place.

Bids for airplane-spraying contracts, with strict specifications, and for kerosene were issued April 20 and opened May 4. Personnel assignments and plane contractor are shown on the table of organization (Table 1).

Zectran was used and was the best of only two chemicals registered for use against the spruce budworm. Approximately 47,000 gallons of Zectran FS15 stock solution (1.5 lbs. actual, each gallon) were shipped in May by Dow Chemical Co. to a railhead on the airport. This was diluted by our crews, 1 part to 9 parts kerosene supplied by the Dead River Co. Storage tanks with a total capacity of 108,000 gallons were set up to insure plenty of spray mixture at all times. The spray mixture was applied at the rate of one gallon per acre, each gallon containing .15 lbs. (2.4 oz.) actual Zectran.

Ten PV-2 aircraft, each with a capacity of 1,200 gallons, and 6 TBM aircraft, each with a capacity of 800 gallons, were used. One helicopter was used to treat 3493 acres along inhabited roadsides and lake shores. TBM's were flown in teams of 3; PV-2's flew in teams of 3 or 2.

Spray-plane teams were guided as in the past by a pair of Cessna planes flying above, each manned by an experienced navigator supplied by Forest Protection Ltd. The eight Cessna planes and pilots were supplied by Maine Aviation Corporation of Portland.

Swath width for each TBM was 367 feet; for each PV-2 it was 550 feet. Spray aircraft flew at 165 m.p.h. and 100-175 feet above the trees. Spray nozzles #8015, which were designed to emit droplets 110 ± micron m.m.d.[1] in size, were used on all fixed-wing aircraft. Helicopter spray nozzles were DZ-23. Spray block size was usually nine miles (N & S) by 2½ miles, although size was often adjusted to compensate for water areas. Flight was normally from north to south and return.

1. m.m.d. = mass median diameter

Table 1. JUNE, 1973, AROOSTOOK COUNTY, MAINE, SPRUCE BUDWORM PROJECT, 450,000 ACRES, (PLUS EXPERIMENTAL SPRAYING)
BASE-Presque Isle Municipal Airport

ACCOMPANYING SURVEYS

OPERATED BY:
STATE OF MAINE
FOREST SERVICE
DIVISION OF ENTOMOLOGY

OPERATING FUNDS:
FEDERAL & STATE

COOPERATION BY:
1) U.S. FOREST SERVICE
NORTHEASTERN AREA S. & P.F.
2) FOREST PROTECTION LTD.
OF NEW BRUNSWICK
3) PRESQUE ISLE CITY MANAGER,
FIRE-POLICE DEPARTMENTS
4) NORTHERN MAINE VOCATIONAL
TECHNICAL INSTITUTE

Forest Commissioner
Fred E. Holt

Deputy Commissioner
Temple Bowen, Jr.

Business Manager
Richard Sawyer

U.S. Forest Service Coordin.
Paul Buffam

Project Director
Robley W. Nash, State Entomologist

Overall Budworm Reduction
Maine Forestry Department

Tech. Ass't
LaBonte
Stark
Trefts

Tech. Supervisor
David Struble

Collectors
Atwood
McMullen
McBreairty
Holmes
Devine
Pratt

Laboratory Analysis
V. Robinson W. Piper
D. Martin H. Congdon
J. St. Peter I. Currie
C. Morneau G. Caron
P. Martin V. Morris
E. Gagnon L. Shaw

Accompanying Surveys for Other Regions.
Same Men Alternating.

Associated Monitoring
Maine Forestry Department
Insects and Plants Dr. Brower

Pre-Spray Contacts
Trefts, McBreairty
Orcutt, Dubey, Locke

Radio Tech.
Cram & Staff

Communications and Weather Base Station - Presque Isle
T. Colpitt &
U.S. Weather Bureau

Sub-stations
A. Peasley
L. St. Peter
R. Tucker
D. Beals
A. Markey

Airport Setup
A. Webb
Townsend, Jr.

Activity Recorder
Marsh-Gooley

Barracks Custodians
L. Michaud
C. Leach

Advice & Assist.
B. Flieger
B. McDougall
Forest Protection Limited

Maps & Progress
J. Walker
J. Hinkley

Airport Affairs, Calibration, Supply & Loading
Chadwick

General Safety & Caution Areas
Lipovsky

Handler's Safety & Condition
Richardson
Batteese

Mixing
W. Bennett
B. Downs
A. Webb

Pumps & Loading
W. Dow-Leader
A. Gibson
J. Cheney
H. Worcester
M. Thornton
L. Rushinol
K. Poland
S. Wheaton
A. Cyr
D. Morse

7 Guide Planes & Pilots
1 Mechanic
D. Roberts
S. Fudge
P. Gallant
L. Merriam
P. Newcombe
J. Nicholson
J. Robinson
P. Rogers
Pointers

10 PV2, 6 TBM, & 1-2 helicopter Spray Aircraft. Pilots, Co-pilots, Mechanics, & Ground Crew - 40 men.

Helicopter Spr[ay]
Contractor*
Supervisor -
Andrew Berry

Plane Spray
Contractor**
Supervisor -
G. Wilson

Plane Advisor
Robinson

Cooks
Mrs. M. Keagan
Mrs. I. Bartley
Mrs. G. Green
Mrs. N. McCrum
Mrs. F. Fitzgerald

Gasoline Supply
Dead River Co.

Maine Helicopters, Inc.
Augusta, Maine

Hillcrest Aircraft Co.
Lewiston, Idaho

Spraying started June 10 a.m. when the required 90% of the larvae were in the fourth and fifth instars (a strong 20% were fifth), as determined by field crews at the Portage and Cross Lake laboratories. It was completed June 19 a.m. Surprisingly the most northerly area (St. Francis) was the first area ready for spraying, based on larval development checks in the various areas.

Weather was so favorable in 1973 that very few possible spray periods were cancelled. This was reflected in the 10-day completion period. We did have 2400 gallons more total plane-carrying-capacity than in 1972, but we also had considerably more "haul distance" in 1973.

Safety was again stressed - generally through police and fire protection, specifically through the provision of Ernest Richardson and Robert Batteese by the Public Health Laboratory. These men kept any of the crew exposed to the chemical under constant surveillance during mixing, loading, and spraying. Invaluable help was given by 20 men of the Fire Control Division and 1 man of the Management Div. in setting up and operating the mixing and loading equipment - also by the radio staff in providing excellent plane-to-plane-to-airport communications.

Spray results were determined by our field staff based at Portage and showed 93% reduction in budworm populations. Good protection of foliage also was obtained; a further reflection of the short completion period. In comparing this figure with that of the first Zectran project in 1972, one should consider that field data were taken differently. In 1972, post-spray data were taken of larvae a few days after a block was sprayed. In 1973 such data were taken after pupation was complete, when 25% moth emergence had occurred. This gave more time for adverse factors to reduce budworm numbers, and possibly eliminated larvae so weakened by the spray that they could not pupate. Actual benefits to treated stands should be further apparent by June of 1974, providing an influx of moths into treated areas did not occur. Degree of new growth and foliage appearing at that time should show the amount of release from budworm feeding pressures. Delay in visual benefits to stands was true in past years when spraying was carried out in the 5th and 6th instar caterpillar stages.

Monitoring of other organisms was conducted by Dr. A. E. Brower. Dr. Brower's data on monitoring the biota in spray areas appear in Appendix A-7. Extensive monitoring of non-target organisms in 1972 indicated no harmful effects. There was therefore no need to repeat it all in 1973.

Research Projects

In addition to supplying funds for the 1973 budworm suppression project, the 106th Legislature also provided funds for related studies in 1973. We contracted with Dr. David Leonard and Dr. John Dimond, University of Maine, Orono, to carry out studies of budworm parasites and spray tests of the efficacy of the biological control agent, Bacillus thuringiensis (B.t.) respectively. They will report on that work separately.

In connection with Dr. Leonard's work, we purchased 10,000 pupal parasites (Brachymeria intermedia) from New Jersey. These were liberated in two equal colonies in Indian Township (Washington Co.) and T6R7 WELS (Penobscot Co.) in late June 1973 when pupation was well under way. This European species had

been found to be present in gypsy moth pupae at Fryeburg, Me. in 1970. It is now being reared in large numbers in New Jersey and will be released to prey on the gypsy moth. The hope is that the B. intermedia releases in Maine will result in establishment of a viable population and successful parasitism of spruce budworm pupae.

Remaining studies were oriented toward use of chemical sprays, principally of Zectran sprays of less volume per acre than the 1973 operational rate, and at a different application time. A detailed account of the experimental operational test of Zectran against the spruce budworm in Maine in 1973 has been printed under the title, "Operational Test of Zectran[R] (Mexacarbate) Against the Spruce Budworm Choristoneura fumiferana (Clem.) in Maine, 1973", by Vaughn F. McCowan, U.S.F.S. and Douglas A. Stark, Me. Bureau of Forestry. A brief account is given herein:

The method of checking results was the same in the test blocks as in the check block (Spray Block #27 - See below). Zectran spray tests were as follows:

(1) Spray Block #27 (Check Block). 9503 acres, Ashland and Squapan. This block was part of the large suppression spray project which received 2.4 oz. Zectran in one gallon of solution per acre. It was sprayed June 14 A.M. by TBM, when 67% of the larvae were in the fifth instar. Post spray data were taken June 18, and showed a 91.7% reduction in population from pre-spray counts. Spray blocks 35, 36 and 37 were removed from the operational suppression project application, and were instead treated as given below:

(2) Spray Block #35. 7894 acres, Nashville. Treated by TBM twice on June 3 A.M. and June 12 A.M., each time at the rate of 1.2 oz. Zectran in 1 quart of solution per acre. On June 3, 88% of the larvae were in the 3rd instar; on June 12, 60% were in the 4th instar-40% in the 5th instar. Post-spray data were taken June 8 for the first application and showed a 39% reduction in population. Post-spray data for the second application were taken on June 15 and 16, and showed a 88% reduction. Over-all reduction in population from both sprays was 93.4%.

(3) Spray Block #36. 7657 acres, Nashville and Ashland. Treated by TBM on June 12 A.M. at the rate of 2.4 oz. Zectran in ½ gallon of solution per acre. Instars were the same as the second spray application in Block #35 above. Post-spray data were taken on June 16, and showed a 93.1% reduction in population levels.

(4) Block #37. 13, 391 acres, Ashland and T13R5. Treated by TBM on June 14 A.M. at the rate of 2.4 oz. Zectran in 1 quart of solution per acre. Instars are given with the Block #27 account. Post-spray data were taken June 19 and showed a 94.4% reduction in budworm populations. A statistical analysis of the four tests described above indicated that spray results were not significantly different from one another.

(5 and 6) On May 21, 1973, just prior to full involvement in preparations for the large Zectran project, the Environmental Protection Agency suggested establishment of two 25-acre Fenitrothion spray blocks for the purpose of gathering foliage protection data toward possible registration of this insecticide against the spruce budworm in the U.S. Zectran was included in the final experiment for comparitive purposes. Sumitomo Chemical Co. supplied the Fenitrothion emulsifiable concentrate which was mixed with water just prior to

loading into the helicopter for spraying. Individual treatment blocks were 80 acres in size, of which 25 acres in the center of the block were designated for taking of data. Blocks E-1 (Ashland) and E-4 (Wade) were treated twice with Fenitrothion, each time at the rate of 2 oz. in 19.2 oz. of emulsion per acre on June 4 A.M. - and June 12 A.M. Instars are given with the Block #35 account above. Blocks E-2 and E-3 (both Castle Hill) were treated twice with Zectran on the same dates as Fenitrothion, each time at the rate of 1.2 oz. (.075 lb.) in 1 quart of solution per acre. Kerosene was the carrier used. Application patterns were assessed by placement of oil-or water-sensitive spray cards in respective spray blocks. Analysis of pre- and post-spray population counts indicated a 63.1% reduction in population resulted in the Fenitrothion blocks; a 84.3% reduction in population resulted in the Zectran blocks. Following spray application, defoliation data were collected from 20 fir trees per sample plot and there were two plots per insecticide application. Five 15-inch branch samples were collected from each of the sample trees following insecticide application, yielding a total of 200 sample twigs per insecticide treatment for analysis of defoliation; a measure of spray effectiveness. Defoliation was divided into four categories: severe, heavy, moderate-light and none (Table 2).

Table 2. A Comparison of Defoliation Rates following Helicopter Applications of Zectran and Fenitrothion

Treatment	Defoliation of 15" Fir Branches				Total No. of
(Insecticide)	Severe	Heavy	Moderate-Light	None	Branches
Zectran	5	23	99	73	200
Fenitrothion	9	60	74	57	200

The number of branch samples in each defoliation category using data from both spray treatments was averaged. The resultant figure was the expected value. The value in each category in each treatment was then subjected to Chi-Square analysis[1], where

$$\text{Chi-Square} = \frac{(\text{Observed Defoliation} - \text{Expected Defoliation})^2}{\text{Expected Defoliation}}$$

E.g. For Zectran - Severe Defoliation:

$$\text{Chi-Square} = \frac{(5-7)^2}{7} = \frac{-2^2}{7} = \frac{4}{7} = .57$$

These values were then all added together and equalled the value 23.22. Degrees of Freedom = the number of classes (no. of sets of data subjected to Chi-Square, or 8) minus 1 = 7. The Chi-Square value of 23.22 with 7 D.F. indicates that chances of a real (not statistical) difference are greater than .005% (Table A.5, Steel and Torrie, Pg. 435); or that the difference between insecticides in prevention of defoliation was significant. Within the limits of this test it would appear that Zectran was more effective in protecting foliage than was Fenitrothion; however, before these results are accepted at face value, several factors should be considered, the primary ones of which are as follows: 1. a mixup in spray-sensitive cards (oil-sensitive and

1. Chi-Square Analysis by McCowan

water-sensitive) for monitoring applications of oil-based Zectran and water-based Fenitrothion, 2. the small size of the test, 3. helicopter treatment by small craft which may or may not be comparable with operational fixed-wing application.

A well-designed experiment of operational spray block size using TBM's or PV-2's to determine possible differences in foliage protection and population reduction between Zectran and Fenitrothion would be much more reliable and meaningful.

LARVAL DEVELOPMENT

Larval and pupal development collections were necessary to determine proper timing of all sprays, including the operational Zectran spray application, the experimental Zectran, the Zectran-Fenitrothion, and the B.t. sprays, and initiation of pre- and post-spray surveys. Development samples were collected at 2-3 day intervals from St. Francis, Garfield, and T8R5 WELS (Figs. 2, 3, 4) in Aroostook Co. A comparison in development between these points was somewhat surprising; the northernmost collection point (Allagash) was 2-3 days ahead of the Garfield collection point and 3-5 days ahead of the southernmost Aroostook Co. point in T8R5. However, these differences became less apparent as the season progressed.

Development collections in the Eastern Region (Fig. 5) of necessity were taken at weekly intervals which precluded accurate determination of instar peaks. It appeared that development in Washington Co. started at least 1 week ahead of the Portage area development points, but ended with only a three-day difference. A preliminary development collection from Washington Co. on May 22 revealed 95% of 112 larvae in the 3rd instar, 5% in the 2nd. Larval development in the Telos Lake spray area was comparable to that in the Garfield-T8R5 areas.

PRE-SPRAY LARVAL SURVEY

Pre-spray larval counts were made at selected points within the spray area for later comparison with post-spray collections. A smaller number of collections were made from points outside of spray areas at the same time for later comparison with post-spray collections outside of spray areas. This comparison was used to determine natural larval mortality during the intervening period. Both comparisons were used in Abbott's formula to determine spray efficacy (See sample problem, Pg.19). Samples from each point consisted of one 18" branch from the mid-crown of each of seven dominant or co-dominant fir. Each branch sample was bagged separately in a plastic bag, then all branches from the same sample point were bagged together with an identifying note enclosed. Samples were kept in a cold storage vault until searched at the labs at Portage and Cross Lake.

Lab personnel were predominantly experienced workers under the direction of an entomologist. Each of the branches from a given sample point was processed separately and continued in number until the cumulative larval counts matched a designated category in a sequential table. In many cases, the larval counts reached a category after only 2 or 3 branches had been searched, thereby limiting the number of branches which needed to be searched.

Figure 2. Spruce Budworm Development, St. Francis - 1973

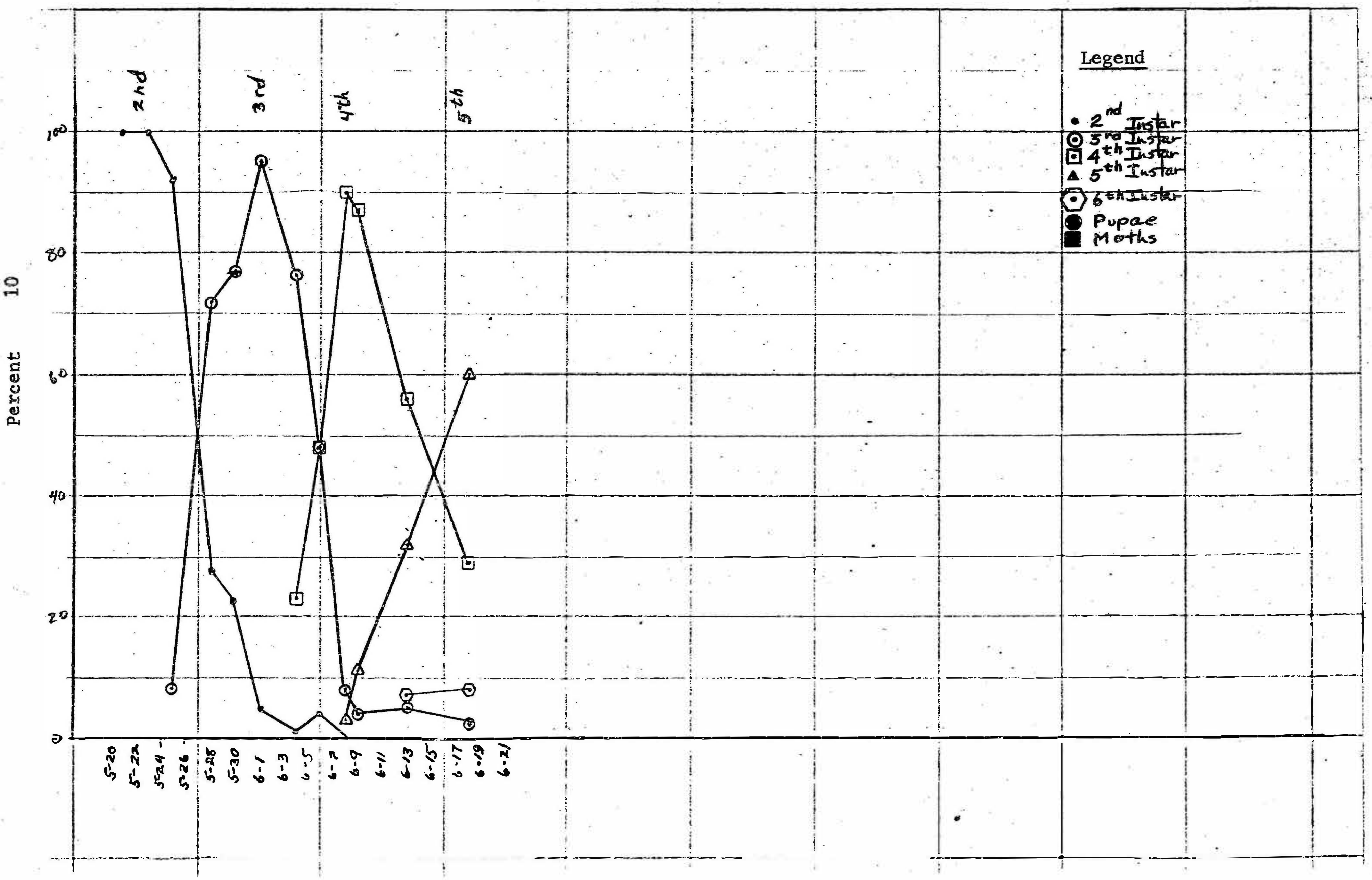


Figure 3. Spruce Budworm Development, Garfield - 1973

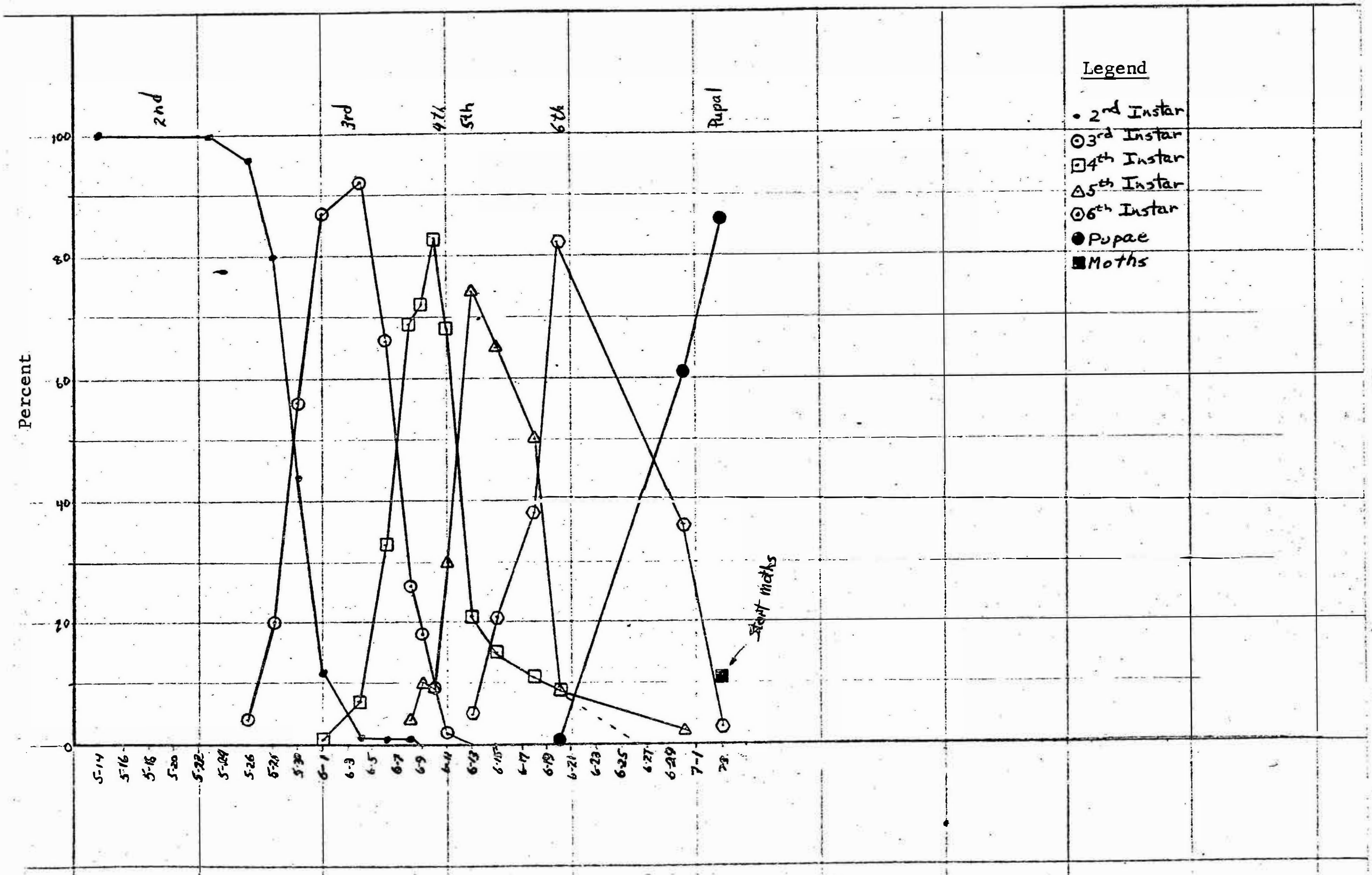


Figure 4.

Spruce Budworm Development - 1973

Knowles Corner Area - T8R5 & T7R5

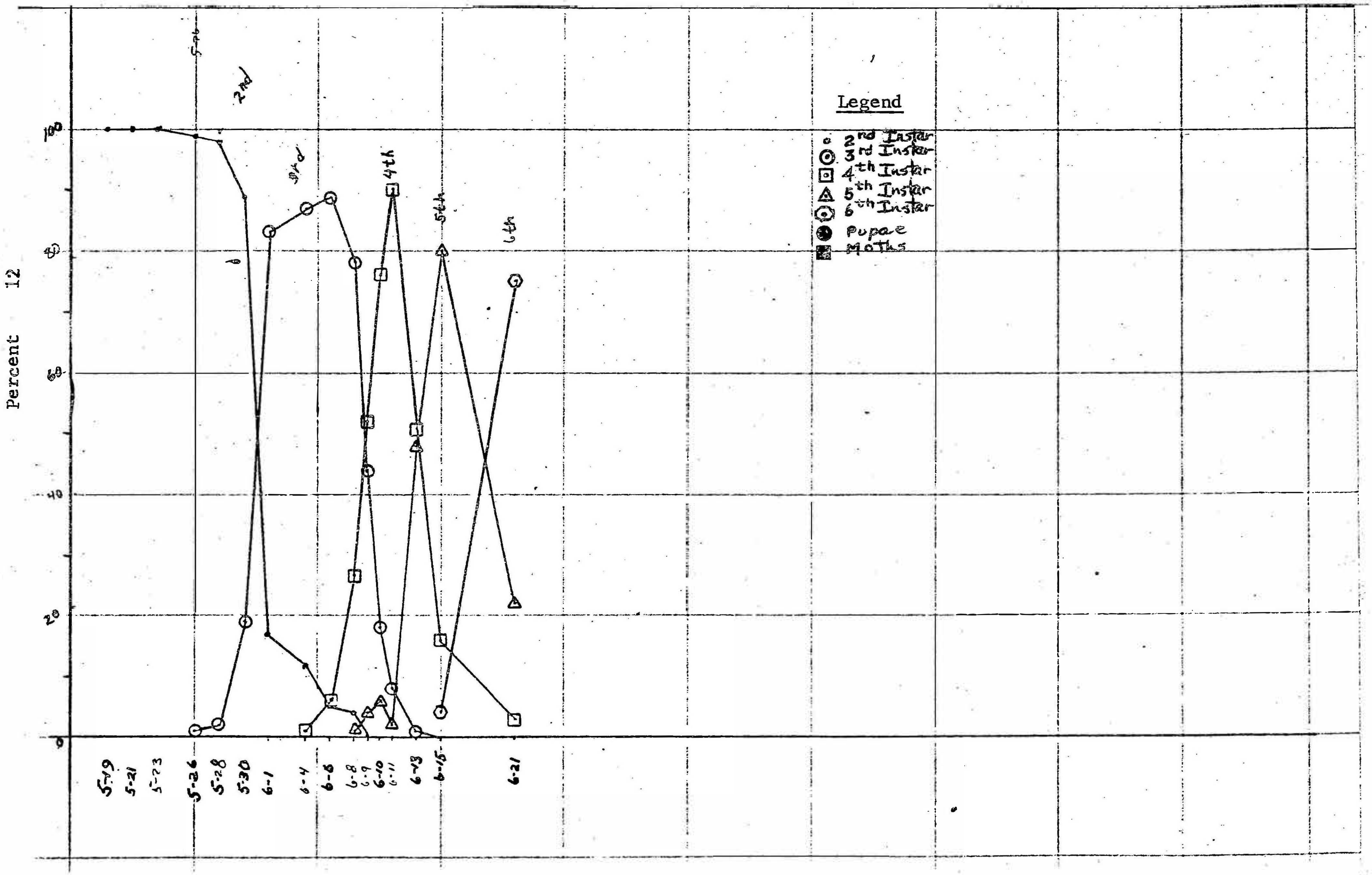
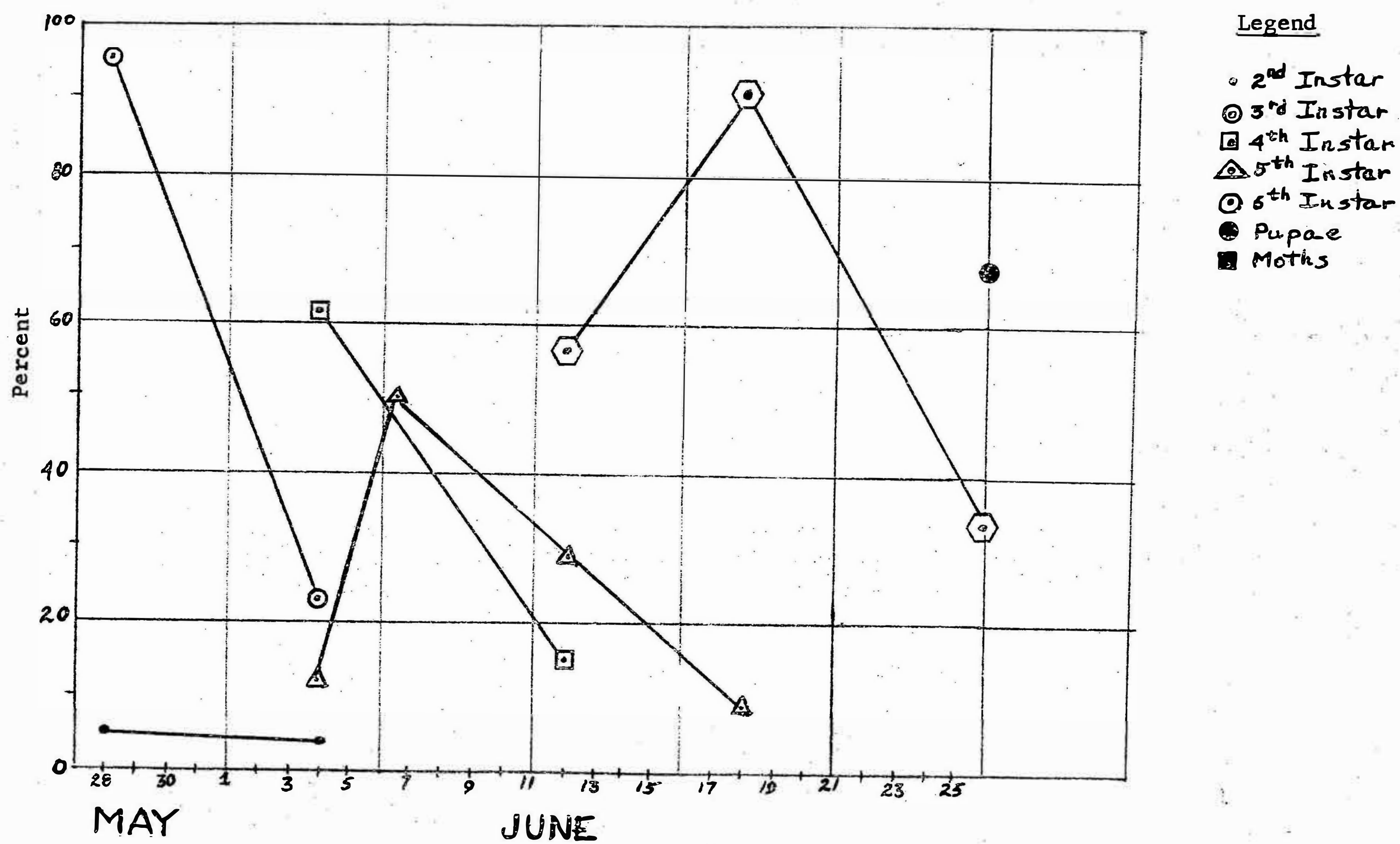


Figure 5. Spruce Budworm Development, Washington Co. - 1973



A small number of collections were searched in the field as they were collected to assess the efficiency of field searching. This showed that when development was approximately 80% in the 3rd instar and 20% in the 4th (about June 7 in Cyr), we had little difficulty in finding all of the larvae. This approach will be investigated further in 1974, possibly using the drum method[1] presently used in Quebec, to increase efficiency and reduce costs.

Field collections were made by Entomology Division personnel from each of the four regions. The Fire Control Division and Industry personnel provided additional manpower necessary to sample the infested acreage which had expanded greatly from 1972. Survey crews were composed of 2 men, with at least one experienced man per crew. Each crew was assigned specific, predetermined sample points. These points were described as to location, and the point was shown on USGS field maps to facilitate collection of the data. The trees from which the samples were taken were then marked with high-visibility flagging so that the same trees could be sampled for post-spray counts. Care was taken to insure that there was at least one sample point in each spray block. Due to the time of year and a wet spring, some of these sample points were quite inaccessible. In some cases a helicopter was used to get a man into such sample points. Even with helicopter support, the more remote areas were not sampled as intensively as those which were near roads.

In addition to regular pre-spray counts, men also were assigned to cooperate with USFS personnel on experimental spray blocks. A different, more intensive sampling method was used in these blocks, as compared to operational spray blocks.

EARLY LARVAL PARASITISM

Rates for parasitism on early-stage larvae were determined by experienced personnel at the Portage and Cross Lake field laboratories by dissection of larvae collected in the pre-spray larval survey and which had been preserved in alcohol. The results of the dissections and species determinations are shown in Table 3 below:

Table 3. An Analysis of Rate and Species Determination of Spruce Budworm Early Larval Parasitism in 1973.*

Category	Total No.	Mean	Standard Deviation	% Parasitism
Larvae	9939	53.44	37.96	-----
Apanteles	860	4.62	3.98	8.6
Glypta	540	2.90	2.61	5.4
Horogenes	8	0.06	0.20	0.1
Other Parasites	12	0.06	0.42	0.1
Total Parasites	1420	7.63	5.89	14.3

*Total No. of samples searched = 186.

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1. DeBoo, R.F., L.M. Campbell and A.G. Copeman. 1973. A Sampling Technique for Estimating Numerical Trends in Larval Populations of Insect Defoliators on Conifers. I. Development and Experimental Evaluation of the Technique. Phytoprotection 54(1): 9-22.

and Martineau, R. and Paul Benoit. 1973. II Modification and Operational Use of the Technique for Extensive Sampling of Spruce Budworm Populations in Quebec. Phytoprotection 54(1): 23-31.

Calculating the average of the % of parasitism for each sample point showed the mean percentage parasitism to be 11.55%, Standard Deviation to be 5.70.

By either method of calculation, early larval parasites obviously are not sufficiently numerous to affect the present epidemic situation.

There appears to have been a slight increase in parasitism particularly of Apanteles and Glypta over that of 1972. Dr. David Leonard, U. of Me. in 1972 found 0.6% parasitism by Apanteles, 4.3% by Glypta and none by Meteorus from 2,069 reared larvae collected outside spray areas. His studies also appeared to show a higher rate of parasitism in 1972 Zectran-sprayed areas than in unsprayed areas. Dissection in 1972 of 6842 reared larvae from spray plots revealed the following rates of parasitism by species: 2.3% by Apanteles, 7.6% by Glypta and 0.2% by Meteorus.

STATEWIDE DISTRIBUTION OF SPRUCE BUDWORM LARVAE in 1973

In conjunction with the intensive systematic spruce budworm surveys conducted by Entomology Division personnel, the fire control personnel make Forest Insect Survey collections from spruce and fir throughout the State. While these samples are not particularly systematic and do not allow computation of density figures, they do give an indication of budworm distribution (Fig. 6) and possible areas of build-up for egg mass sampling.

POST-SPRAY (PUPAL) SURVEY

Post-spray spruce budworm populations were sampled beginning at that point when 20% of the moths had emerged from the pupae. On July 3, 10% moth emergence had occurred, so post-spray sampling commenced on July 5. Samples were collected from the same trees and after the same manner as the pre-spray samples, except that two 18-inch branches per tree were collected.

The number of larvae, pupae, and empty pupal cases were counted for each two-branch sample and were compared with a sequential table which took into account natural loss of pupal cases. Populations per 100 sq. ft. of foliage were thereby determined and compared with pre-spray counts from the same points. Searching was done in the field and eliminated possible mortality due to excessive handling and storage of samples.

Live larvae and pupae which were collected were taken to the laboratory for dissection to determine the presence of parasitism. These data allowed for correction of the number of adult survivors from the samples from which they were collected.

There were neither sufficient numbers of live budworm collected during this survey accurately to assess the percentage of late larval and pupal parasitism, nor was the post-spray survey designed to determine rate of parasitism. Also, parasite data were not available from those pupal cases which were empty, or were broken and lost when the parasites emerged. It is therefore recommended that future sampling schemes include a late larval sample from a limited number of sample points outside of spray areas; such a scheme

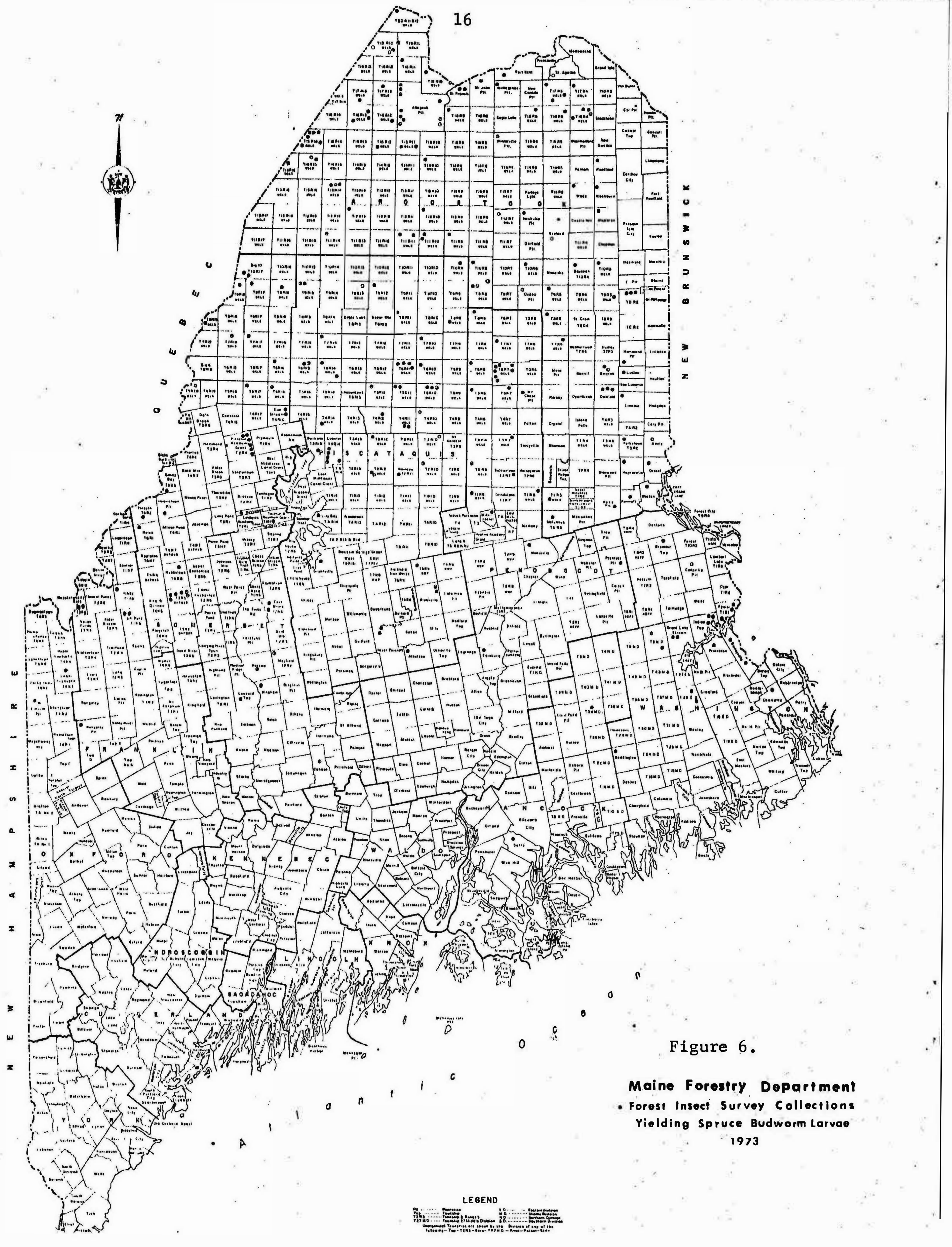


Figure 6.

Maine Forestry Department
• Forest Insect Survey Collections
Yielding Spruce Budworm Larvae
1973

designed specifically to determine rate of late larval-pupal parasitism by parasites which deposit eggs on or in late larvae. The larvae so collected should be reared on artificial media and the % of emerging parasite species calculated. A later scheme specifically designed to determine rate of pupal parasitism could also be made to include those parasites which lay their eggs on or in budworm prepupae or pupae.

EFFICACY OF THE OPERATIONAL ZECTRAN APPLICATION

Quantitative data on budworm population reduction by spraying were derived from pre- and post-spray collections taken inside and outside the spray area. Pre-and post-spray collections were taken at 190 points; 141 of which were inside and 49 of which were outside the spray area. Mean numbers of larvae (pre-spray) and pupae (post-spray) per 18" tip were calculated at each point. Means were then calculated for the entire spray area, the 49 check points, and selected groupings of spray blocks. Mean numbers of larvae (pre-spray) and pupae (post-spray) for each selected grouping are given in Table 4. These data were used to determine the % budworm living in check and treated areas.

Spray efficacy was calculated using a modification of Abbott's formula that would account for differences in population levels and mortality rates. (See sample calculation in unpublished report "Recommendations for Improvement of Spruce Budworm Population and Damage Survey Methods in the State of Maine", by Dr. Gary A. Simmons, April 19, 1973, filed with Maine Department of Conservation, Bureau of Forestry, Division of Entomology). Efficacy was determined for the project as a whole and for 5 selected groupings of spray blocks. Mean spray efficacy and limits (based on 90% confidence intervals) are given in Table 5.

Procedure for Determination of Spray Efficacy

The procedure used to determine spray efficacy may be seen in the following calculations, where the basic data were taken from Table 4; Over-all (Spray area) grouping and Over-all (Check points) grouping.

The % budworm calculated as living in the check plot and % budworm living in the treated area were inserted into Abbott's formula to determine over-all efficacy as may be seen from the problem on page 19.

Table 4. Mean numbers of larvae (pre-spray) and pupae (post-spray) by spray grouping.

Area or Grouping	Number of points	Mean larvae per 18" tip (pre-spray)	Mean pupae per 18" tip (post-spray)
Over-All (Spray area)	141	28.812	.744
Over-All (Check points)	49	12.614	4.618
Blocks 1-4, 45, 46 St. Francis	22	44.682	.814
Blocks 24-40 Squapan	48	15.600	.470
Blocks 18-23 Squapan	19	17.584	.373
Blocks 41-44 Square Lake, Cyr & Connor	23	43.382	1.621
Blocks 5-17 Telos	29	35.437	.596
AM Spray	56	32.53	.890
PM Spray	22	21.35	.160

Table 5. Spruce Budworm - Spray Efficacy - 1973

	Number Pupae Alive Per 18-Inch Tip		Min. - Max % based on 90% confidence intervals		
Area	Check Plot Ave. ± S. E.	Spray Block Ave. ± S.E.	% Kill	Min.	Max.
1-4,45,46	4.62±1.16	.81±1.18	95.0	94.7	96.6
24-40	4.62±1.16	.47± .28	91.8	91.1	95.0
18-23	4.62±1.16	.37± .25	94.2	92.4	97.6
41-44	4.62±1.16	1.62± .60	89.8	86.4	95.0
5-17	4.62±1.16	.60± .23	95.4	94.4	97.8
Overall	4.62±1.16	.74± .13	93.0	92.4	94.0

Calculation of Operational Spray Efficacy

Check Area		Spray Area	
mean larvae per 18" tip (Pre-spray)	mean pupae per 18" tip (Post-spray)	mean larvae per 18" tip (Pre-spray)	mean pupae per 18" tip (Post-spray)
12.614	4.618	28.812	.744

Defining X

Let X = % living in the check plot where $\bar{X}_2/\bar{X}_1 \ .100 = X$

$\bar{X}_1$ = mean number of larvae per 18 inch tip alive in the pre-spray survey (in check plot)

$\bar{X}_2$ = mean number of pupae per 18 inch tip alive in the post-spray pupal survey (in check plot)

$$X = \frac{\bar{X}_2}{\bar{X}_1} .100 = \frac{4.618}{12.614} .100 = 36.61\%$$

Defining Y

Let Y = % living in the treated area where $\bar{Y}_2/\bar{Y}_1 \ .100 = Y$

$\bar{Y}_1$ = average number of larvae per 18 inch tip alive in the pre-spray larval survey (treated plot)

$\bar{Y}_2$ = average number of pupae per 18 inch tip alive in the post-spray pupal survey (treated plot)

$$Y = \frac{\bar{Y}_2}{\bar{Y}_1} .100 = \frac{.744}{28.812} .100 = 2.58\%$$

Determining % killed by the spray

$$\text{\% killed by the spray} = \frac{X-Y}{X} .100$$ (from Abbot) 1925

$$\frac{X - Y}{X} .100 = \frac{36.61 - 2.58}{36.61} .100 = 93.0$$

Comparison of Efficacy of Morning vs Evening Spraying

Dr. Gary Simmons, U. of M., Orono, and Henry Trial, Jr. made an analysis of the efficacy of the spray on areas sprayed in early morning hours vs. late evening hours. Twenty-two points mapped as evening spray were compared to 56 morning spray points. Beginning populations in these two groupings were found to be significantly different. To minimize the effect of this variation, a point-by-point analysis of efficacy was made. Mean spray efficacy for morning and evening was then calculated. The mean efficacy for morning application was 92.6%, and the mean for evening application was 96.7%. Evening application was significantly better than morning application in terms of efficacy ($t=1.75$, $p < .05$).

This information, at best, is preliminary. Since these were very limited analyses, future statistically designed and closely controlled experimentation is warranted to determine possible true differences between the two times of application.

SPRUCE BUDWORM AERIAL DEFOLIATION SURVEY - JULY

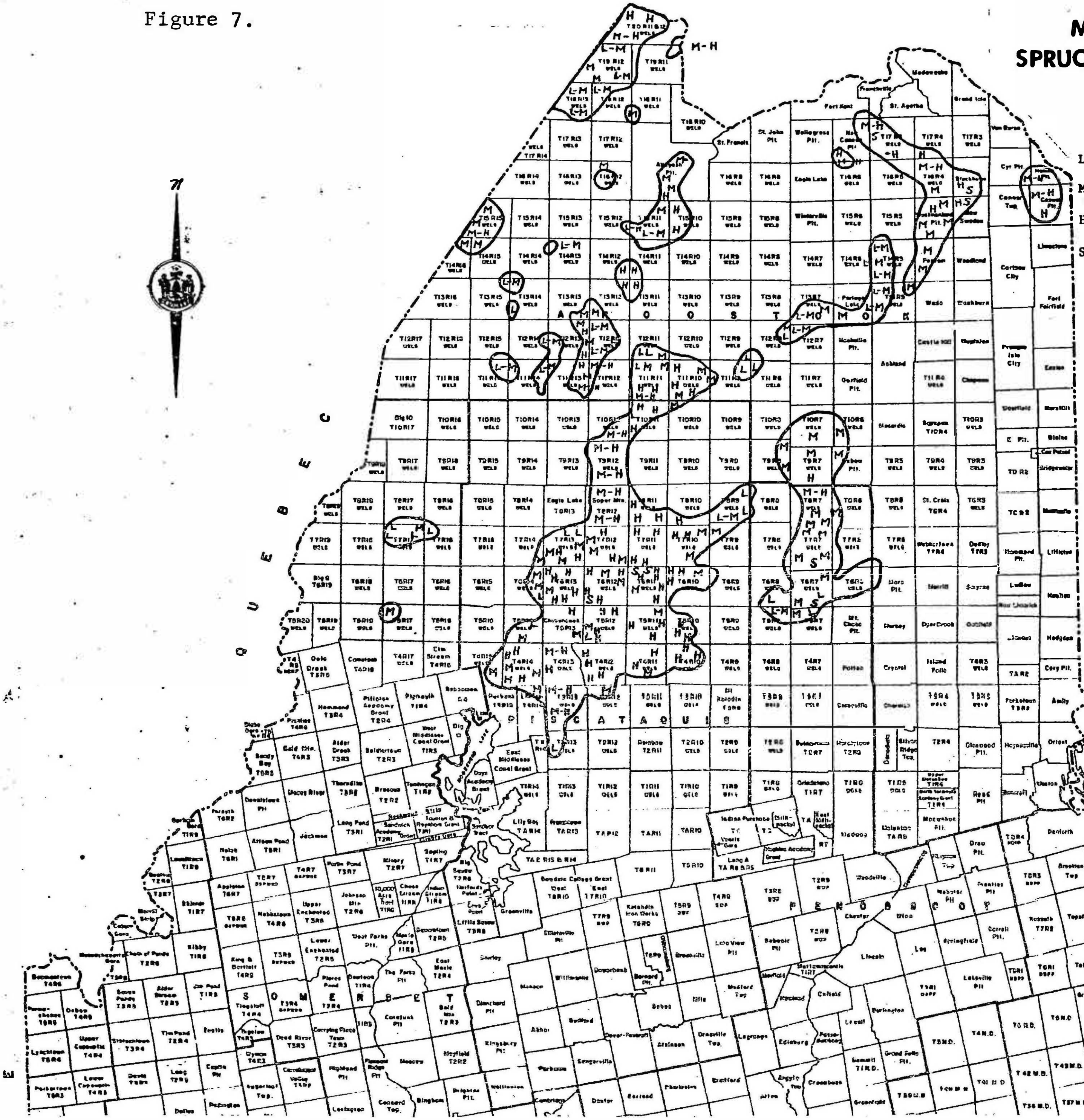
The regular annual aerial survey to determine areas defoliated by spruce budworm larvae normally is conducted as early in July as possible when most of the budworm-clipped dead needles are still adhered to webbing and twigs and prior to weathering by wind and/or rain. The peak of discoloration occurred sometime around the first of July and was particularly striking at this time in the T11R11 (Musquacook Lakes) area.

In conjunction with an exploratory Spruce Budworm Survey Study conducted in Aroostook County by Forestry and Industry personnel and the James Sewall Co. of Old Town, forest type and defoliation intensity data were recorded on a 20-pen Esterline-Angus Operation Recorder carried in a Cessna 180 containing a crew of 4; pilot, navigator, observation man recording forest type and an observation man recording damage. A total of 23 flight lines each 3 miles apart were flown east and west from Township 17 south to Township 6 and from Range 3 to Range 8. Damage classes were recorded as severe, moderate or light. Two crews alternated taking of data. Due to rain or overcast weather, this survey was not started until July 6 and was completed on July 7 in approximately 11 hours of flying time. Defoliation data collected in this study were first transferred to a USGS base map, then to a map of statewide defoliation (Fig. 7). In addition to the above area, additional areas of defoliation were aerially surveyed around mid-July and sketch-mapped on USGS maps or highway atlas maps (scale: 1"=3 miles) from Cessna 180's and/or Bell 47G3 helicopters. The defoliation survey continued into the third week of July, but because of extremely wet and windy weather in early July, light to moderate degrees of defoliation were somewhat difficult to pick up at this time.

In general, the extent and severity of 1973 larval feeding damage increased over that in 1972. For example, the Washington Co. area increased from 40,625 acres of moderate to severe defoliation in 1972 to 66,912 acres in 1973. Light to moderate defoliation was present outside these heavier defoliated areas.

Figure 7.

MAINE BUREAU OF FORESTRY
SPRUCE BUDWORM DEFOLIATION SURVEY
JULY, 1973



LEGEND

L = LIGHT DEFOLIATION (1 - 20%)

M = MODERATE DEFOLIATION (21 - 50%)

H = HEAVY DEF. (51% - 80% + SOME SHOOT AXILS MISSING)

S = SEVERE DEF. (81% + AND MOST SHOOT AXILS MISSING)

SPRUCE BUDWORM MOTH FLIGHTS AND LIGHT TRAP CATCHES

Spruce budworm moth flight catches were recorded from 24 light trap stations operated during July, 1973, and from 5 U.S. Custom Stations along the U.S.-Canadian border (Fig. 8). Moth flights were much more common in 1973 than for many years, and counts of over 1,000 moths per night per trap were not uncommon (Table 6). The period of highest flight activity in central and northern Maine was between the nights of July 4-5 and July 10-11.

A tremendous flight of spruce budworm moths[1], which evidently occurred during the evening of July 17-18, was reported off the coast of eastern Maine and on off-shore islands. Many female moths were gravid and deposited large numbers of egg masses on building surfaces. Moth depth was reported at 2-4 inches on Machias Seal Island southeast of Cutler. Between Schoodic Point, Me. and Grand Manan Island, N.B. 20 to 50 moths per square foot were observed floating on the ocean surface for nearly 60 miles along the Maine coast and at least 14 miles out to sea from the shoreline.

EGG MASS AND GROUND DEFOLIATION SURVEY

The annual egg mass survey provides the first definite indicator of population trends for the following year. The egg mass deposit is the basis for prediction of the location of next year's larval population, it's numbers and the feeding intensity which may be expected. It is coordinated with the collection of current and past defoliation - top kill - tree mortality data, and is a component of the hazard rating system; the basis for establishment of areas proposed for spraying.

The 1973 egg mass survey was begun the first week of August after all the eggs had hatched and the larvae emerged. By starting the survey after larval emergence, all possible natural control factors were accounted for.

If the egg mass survey continues too late into the fall, the data tend to be biased due to a problem in differentiating between new egg masses which are weathered, from those old, protected egg masses from the previous year which still remain on the needles. Sampling was completed by the end of August, thereby minimizing such problems.

Egg mass sample points were most intense from pre-selected areas which had shown moderate-severe current defoliation in July. These points generally were about 3 miles apart (one every 9 sq. mile, or 6,000 acres). Some sampling was also done within the 1973 spray area to determine residual populations as well as possible moth flights into the area.

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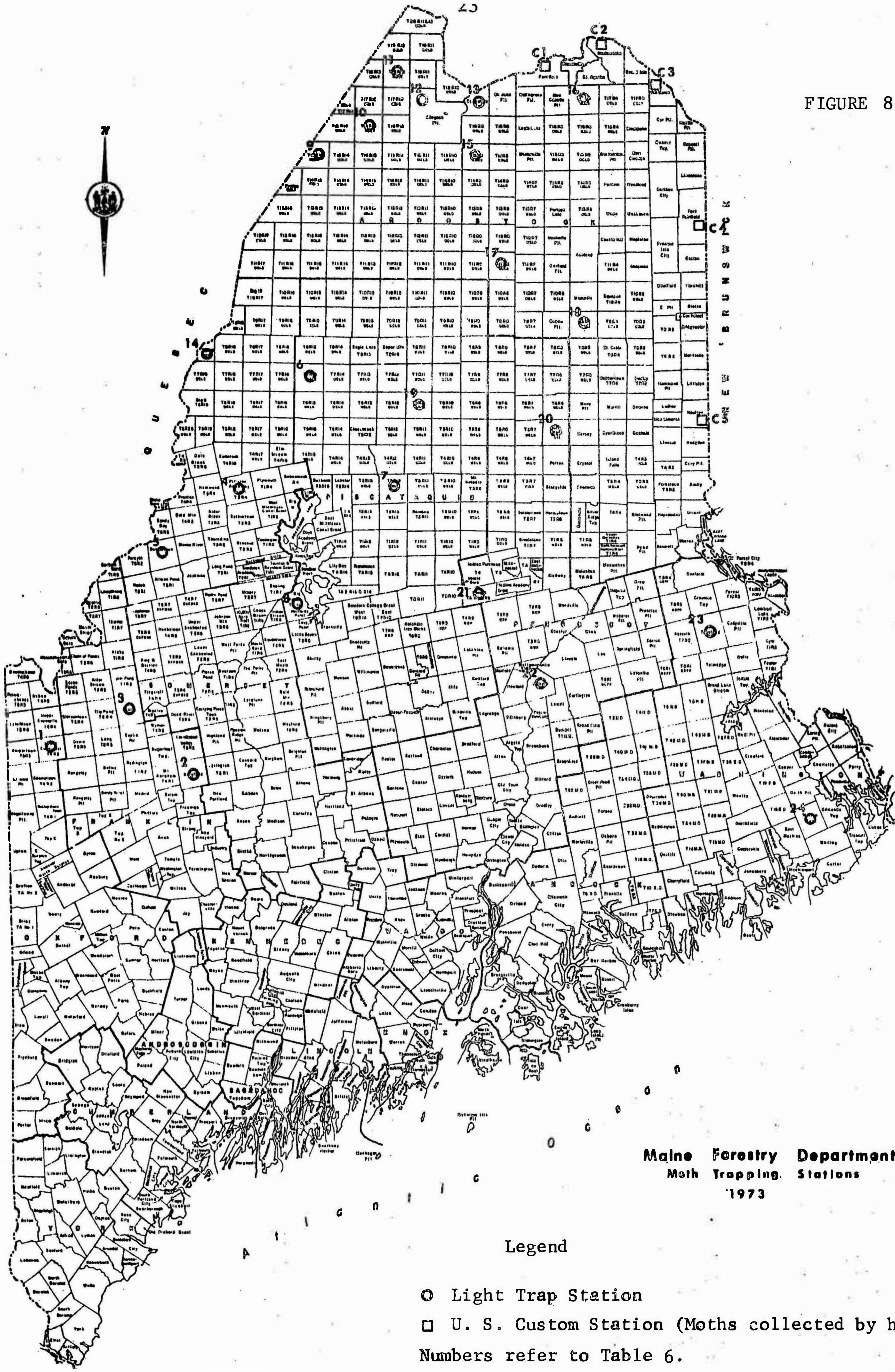
1. This account excerpted from "Forest Insect and Disease Notes" No. 1 of 1973 - December. Me. Bureau of Forestry, Augusta, Me.

FIGURE 8.



Legend

O Light Trap Station

□ U. S. Custom Station (Moths collected by hand)

Numbers refer to Table 6.

Table 6. SPRUCE BUDWORM MOTHS IDENTIFIED FROM LIGHT TRAP COLLECTIONS DURING 1973

DATES OF COLLECTIONS

	JULY																															AUG.	TOTAL
TRAP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	
1. Lower Cupsucptic	2	1					20	14			4																						41
2. Kingfield	2	2		2	2	2	12	29	9	114	3										1		2	20	5		4						209
3. Eustis	4		1			2	22	39		13	12	24			6	20																	143
4. Pittston Farm							49	8	9	1			28	1				2						2	1			8					109
5. Dennistown																	10	10	55	5		21	12		69	24	2	3	6				217
6. Caucomgomac(T7R15)																				1	1	1				1		3					7
7. Chesuncook Dam(T3R12)			6				2			8	64								1	1					4	1	1						88
8. Squaw Brook(T2R6)						25	32	24	253	13	228	7	7	2	3					1	1			6	54	13		3					672
9. T15R15					3	5	13		36	4	9	2	2	17	6		1		1	1													100
10. Chimenticook Stream(16R13)					1	4	18											3							1								27
11. Rocky Mtn. T18R12)				10	25	1	1	16		3				1	1										1	2	2	1					64
12. Allagash (T17R11)							1	3																									4
13. St. Francis	4		4	8	51	108	22	12	33	17	112	70	86	59	112	118	52		1		3	4		1		1	1						879
14. Somerset Co.(T8R19)						2	78	71	532	2	210	5	1	6				4	3			5		3	1								923
15. DeBoulie Mt.(T15R9)			3		106			17	16	18			18	19	41	15	42	58	14		25	12			1	25	13	1	9	1	1		455
16. Cross Lake(T17R5)(Black Light)					1177	470	136	1368	4500±	585±	1000±	285	70	800±	65±	110±	70±	6	8	55	65	30	2	20	160	30	4	13				1	11,030
17. Round Mt. (T11R8)			1	51	1	9	8		13	34	67	4	2					2	1		4	2	13		5	2	1						220
18. Camp Dana(T9R5)(Oxbow)			1	5	6	156	40	4212	820	81	1098	32	13	26	17	17		2	23	10	3	3	2	2	14	4	2						6,580
*19. Round Pond Telos(T6R11)			66	429		137	413	847		83	271			13	10			31															2,300
20. Shin Pond(Mt.Chase Plt.)							675±	3000±	29	26	8	11	6		3		1								25								3,784
21. Long A. Twp.(Millinocket)						1		1	61	73	85		9	1	1		1	1	8	3	7	2	2	5	13	13	15	5	3				310
22. Enfield			2				1	4			10					1																	18
23. Topsfield			1			5		3	5	2	4	2	8	17				1				1		1									50
24. Marion							5	8	53	324	266	26	3	1	1			6	31	11	24	2	13	27	8	2							811
*19 Extra Telos Camp (Operated 1 night only - July 10 -------------- 10,000)																																	10,000
C1 Fort Kent Customs																																	0
C2 Madawaska "																																	0
C3 Van Buren "																																	0
C4 Fort Fairfield Customs																																	0
C5 Houlton Customs								16							3																		19
TOTAL	12	3	85	505	1372	927	1548	9692	6369	11,401	3451	468	253	963	269	281	177	126	146	88	134	83	46	87	362	118	45	37	18	1	1	1	39,069

Egg mass samples consisted of one mid-crown branch from each of 4 dominant or co-dominant fir trees per sample point. Each branch was cut up and put in a separate paper bag with the dimensions of the foliated portion of each branch recorded on the paper bag with a felt marker. Collections were sent to the Portage or Cross Lake laboratory where they were searched by experienced lab help. As the egg masses were found, the needles to which they were attached were detached from the branch and the egg mass placed in one of the following categories:

1. Old; from previous year's populations.
2. New - healthy; no significant mortality.
3. New - parasitized; significant percentages of the eggs in the mass parasitized.
4. New - dead of other causes (DOC); a significant percentage of the eggs damaged or destroyed by predation, etc., so as to prevent larval development.

The final determination of the proper category for the egg masses was made by an entomologist in the laboratory.

The number of new, healthy egg masses per square foot of foliage was calculated separately for each branch of the sample, and then converted to a per-100-sq.-ft. figure. This value from each branch sample was compared with values in a sequential table. Searching of additional branches ceased when the cumulative egg count on branches searched fell into a sequential category of low, medium, or high. The average number of egg masses per-100-sq.-ft. of foliage was then calculated and converted to an infestation level as shown in Table 7.

Table 7. Spruce Budworm Egg Masses per 100 Square Feet of Fir Branch Surface and Infestation Levels.

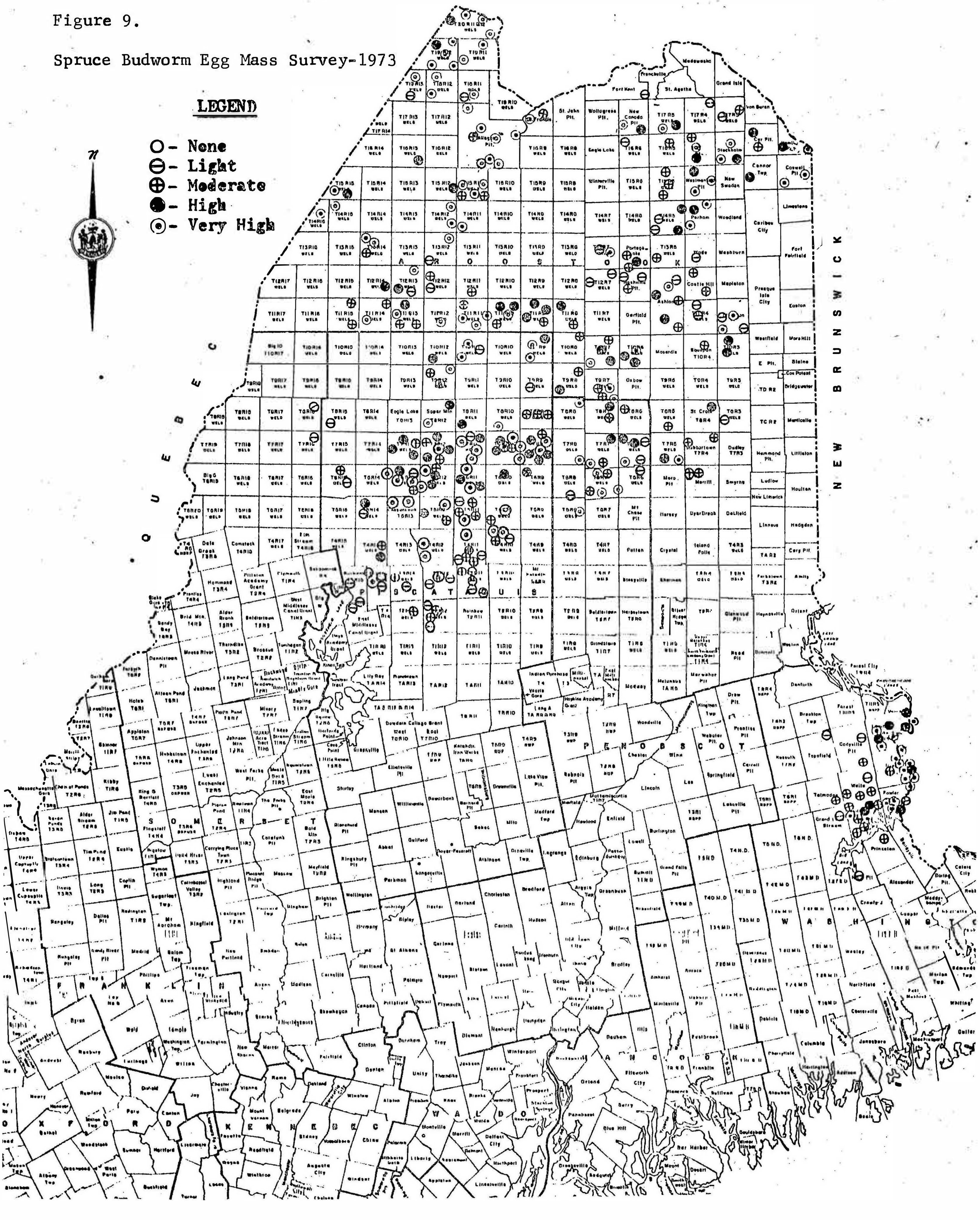
No. Egg Masses Per 100 Sq. Ft.	Infestation Level
0	None
1- 99	Light
100-239	Moderate
240-399	High
400+	Very High

In some of the areas the infestation was much more severe than even the "Very High" category; a few sample points had values of over 2000 egg masses per 100 sq. ft. of branch surface. When one considers the number of square feet of foliage in the average fir tree with this category of egg masses, the potential larval population in such a tree is astronomical. Figure 9 shows the results of the 1973 egg mass survey statewide.

Following completion of the egg mass survey, an analysis of the data concerning the mortality factors of the egg masses was made. The values for the individual branches within a sample point were grouped so that each sample

Figure 9.

Spruce Budworm Egg Mass Survey-1973



point was given equal statistical weight. The procedure allowed analysis of 205 sets of variables.

Analysis was done by averaging the percentage parasitism at each point. These data showed the parasitism to be 0.70%. Standard deviation was 2.07. Analysis correlation coeffecient between the 6415 egg masses and the 45 parasitized had an r value of 0.12, which is not significant at the 5% level.

Mortality due to the D.O.C. category was 1.15%, with a standard deviation of 2.97. Combined mortality was 1.85% which obviously did not affect significantly the prevailing epidemic situation.

Prior to spraying in 1973, the mean number of larvae per 18" twig from 260,000 acres of the eastern Aroostook Co. spray area was 15.6 - 17.6, 20 in the Washington Co. unsprayed infestation, and 30 - 40 from the St. Francis, Telos, and Square Lake spray areas. Barring unforeseen causes of larval mortality in 1974 therefore, the high egg mass counts in 1973 unsprayed areas and low rate of egg parasitism indicate a much higher potential mean larval count per 18" branch is possible in 1974 than existed in 1973. Coincident with this larval potential is the potential for severe defoliation in 1974.

PROJECTED SPRUCE BUDWORM SITUATION FOR 1974

Tree Condition Data and Hazard Rating

Data pertaining to current defoliation, past defoliation, tree vigor, top mortality and tree mortality (Table 8) are taken at egg mass sample points at the time of the egg mass survey. These variables, plus the infestation levels determined from the egg mass counts, are assigned numerical values which form the basis for a numerical hazard rating system (Table 9); the criteria by which proposed spray areas for the following year are determined.

The arithmetic sum of the numerical values assigned these variables from each point constitutes the hazard rating for the given point. A value of 12 - 16 is justification for inclusion of that area in a spray project proposal; values of 17 - 21 are even more justified for control action and warrant consideration for pre-salvage possibilities. Values of 21 - 24 are realized when mortality has already started and significant mortality will continue. Such areas are in need of detailed cruises by foresters managing the involved lands. The purpose of the cruises would be to determine salvage possibilities involving both extent and accessibility of areas justifying salvage, as well as the affect of salvage on the overall harvesting and management plans of the foresters. Figure 10 indicates the results of the hazard rating for all areas infested in 1973.

Fall Aerial Damage Survey

In addition to previously mentioned surveys, an aerial damage survey was conducted over 1974 proposed spray areas in late September or early October. This survey is an adjunct to the hazard rating, and allows the drawing together of separate points of similar hazard into cohesive areas of similar hazard.

Areas of severe damage show up grey-brown in comparison to the green color of healthy trees. The balsam woolly aphid-attacked fir in the Washington Co.

TABLE 8

SPRUCE BUDWORM DEFOLIATION - DAMAGE AND RECOVERY GUIDES
(fir)

For Current Defoliation Use the Following Guides:

Trace - T	0 - 5%	Defoliation	
Light - L	6 - 20%	Defoliation	
Moderate - M	21 - 50%	Defoliation	
Heavy - H	51 - 80%	Defoliation	+ some shoot axils missing.
Severe - S	81% +	Defoliation	+ MOST shoot axils missing.

For Previous Defoliation - Damage on Fir, Use the Following Categories:

Category	Damage
Trace - T	Little or no apparent damage except to current year's foliage.
Light - L	Some defoliation evident on previous growth, particularly on previous year's growth. No bare top.
Moderate - M	Thin crown; short, bare top; defoliation evident on at least two previous year's twigs.
Severe - S	Marked defoliation on two or more year's growth; crowns thin and grayish in appearance.
Dead Tops	This has to do with general tree top condition in the area sampled and not necessarily just the condition of those trees sampled.
Dead Trees	This also has to do with general tree condition and not necessarily just the condition of those trees sampled. (Condition of trees in the area).

For Recovery of Foliage After Spraying, or Vigor of Fir Trees in Unsprayed Areas Use:

Good - G	Current foliage apparently normal or nearly normal. Trees evidently capable of rapid recovery.
Fair - F	Shoot production moderately affected, obviously less vigorous but with evidence of ability to recover.
Poor - P	Current shoots present but sparse. Tree clearly demonstrating serious deterioration of growth capability. Buds for production of next year's growth small and weak or lacking.

TABLE 9. 1973 SPRUCE BUDWORM HAZARD RATING SYSTEM

MAINE BUREAU OF FORESTRY - ENTOMOLOGY DIVISION

Category		Hazard Value
Current Defoliation		
Trace		0
Light		1
Moderate		2
Heavy		3
Severe		4
Previous Damage		
Trace		0
Light		3
Moderate		6
Severe		9
Dead Tops		12
Dead Trees		15
Tree Vigor		
Poor		+1
Fair		0
Good		-1
Egg Populations		
	No. Mass/100 sq. ft. - Infestation Level	
None	0	0
Light	1 - 100	1
Moderate	101 - 240	2
High	241 - 400	3
Very High	400+	4

Hazard Rating	Range of Total Values
Very Low	0 - 4
Low	5 - 7
Moderate	8 - 11
High (Spray Recommendation)	12 - 16
Very High	17 - 21
Severe	22 - 24

area made the survey somewhat more difficult there, but such trees could be distinguished from budworm-damaged trees by their generally grouped pattern and loss of apical dominance which produces the "flat-top" condition.

Bureau of Forestry helicopters generally are used for this survey because of the excellent visibility possible, relatively low rate of speed, and ability to fly at tree-top height; however, Cessna 180's allow for faster coverage and were most efficiently used where stand condition and composition were fairly extensive and uniform. Tree and top mortality, and trees under stress easily can be seen and recorded by experienced observers using either aircraft.

Soaking-out of Overwintering Larvae

The final survey effort is the overwintering larval survey which helps fill in and verify previous surveys. This survey may be started anytime after early September when larvae are all in their overwintering hibernacula. It is most useful for making winter collections by snowmobile in areas not readily accessible by any other method.

Sample collections provide additional hazard data concerning proposed spray areas. By measuring the density of overwintering larvae per sq. ft. of foliage, and converting this to the number of larvae per 100 sq. ft., the infestation level from each specific sample area can be predicted. These infestation levels are given a numerical value which is used in the determination of a hazard value for that collection point in a manner similar to that in determination of egg mass hazard values.

The field sampling procedure is identical to the egg mass sampling scheme; one branch is collected from each of 4 dominant or co-dominant fir trees. Visual searching is impractical and virtually impossible with any degree of accuracy. Instead, foliage from each branch sample is immersed in a 2% lye and water solution at 50 degrees Centigrade and agitated hourly. After soaking for about 7-8 hours, the foliage is screened and rinsed. The lye solution dissolves the hibernaculum, and the larvae float free. By progressive screening, the majority of the plant debris is separated from the larvae. A separatory technique utilizing a benzene-water interface is used which holds the larvae and allows most foreign material to pass through. Larvae and fairly clear liquor are then placed into a filter-containing Büchner funnel under suction. Larvae and a small amount of debris are collected on the filter paper, where they are easily counted under a binocular microscope. Larval density infestation levels and hazard values are given in Table 10 below.

Table 10: Overwintering Budworm Larval Density, Infestation Levels and Hazard Values from Soaking-out Samples - 1973.

Overwinter Larvae / 100 sq. ft.	Infestation Level	Hazard Value
0	Nil	0
1-100	Low	1
101-300	Medium	2
301-650	High	3
651+	Extreme	4

All of the soaking-out samples have not been processed as of this writing. The results will therefore be distributed as an addendum at a later date. When these data do become available, they will be added to and update those from previous surveys.

At the present time there are 14 areas proposed for spray treatment in 1974 (Fig. 11) and these amount to 430,000 acres. More detailed maps of these areas may be seen on maps A-1 through A-5 in the Appendix.

SUMMARY

In June, 1973, 450,000 acres of spruce-fir forest were sprayed operationally to control the spruce budworm at a cost of $2.71 per acre total cost, of which $2.61 was the direct cost. Presque Isle was the base of operations. Zectran FS15 was the insecticide used and was applied with kerosene as the carrier at the rate of 1 gallon per acre, each gallon containing .15 lbs (2.4 oz.) actual Zectran. Aircraft used were TBM Avengers (6) and PV-2's (10). Excellent spray weather enabled start of spray operations on June 10 and completion on June 19. Spray efficacy of the operational project was determined to be 93% using Abbott's formula.

In addition to the operational project, several experimental tests were conducted, each of operational spray block size but with different rates of application. All tests of this series resulted in population control equivalent to that of the operational project. The test spray mixture composed of 2.4 oz. Zectran in 1 quart of spray per acre, rather than the usual gallon, is therefore justified for full operational use in 1974.

A small helicopter-applied test to compare population control and foliage protection between Fenitrothion and Zectran indicated better results with Zectran under the conditions of this test. A similar but larger and better-designed test in 1974 under operational conditions might prove to be a more meaningful comparison between these two chemicals.

A test of <u>Bacillus thuringiensis</u> without the enzyme chitenase was also conducted in an operational-sized block south of Square Lake. Results of this test will be reported on separately by Dr. John Dimond, U. of M., Orono. Dr. David Leonard, U. of M., Orono will also report separately on parasite releases and studies in Washington and Aroostook Counties in 1973.

Mean percent parasitism of early larvae was found to be 11.55%; late larval-pupal parasitism was not determined. Egg parasitism was 0.7% and combined egg parasitism-predation was 1.85%.

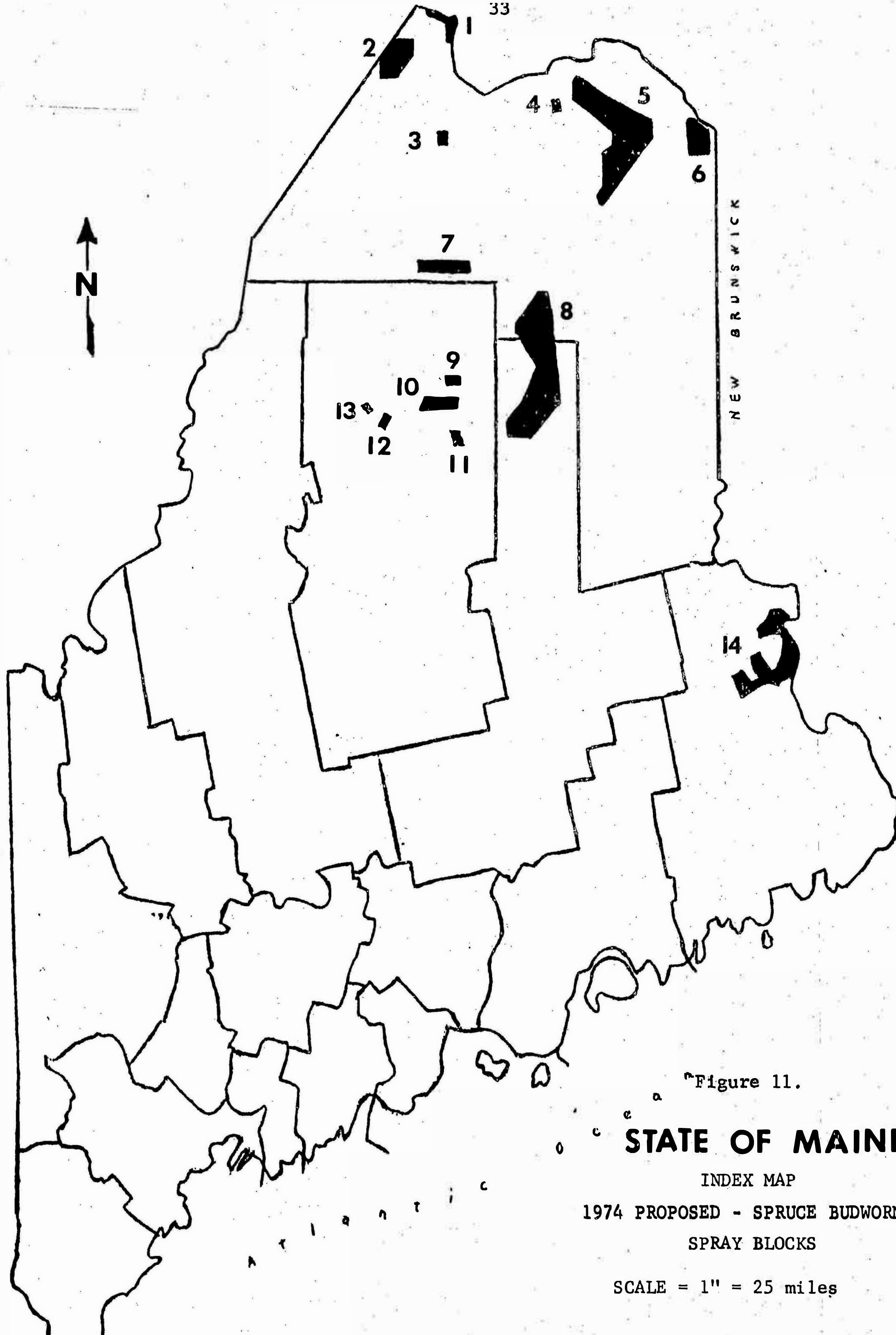


Figure 11.

STATE OF MAINE

INDEX MAP

1974 PROPOSED - SPRUCE BUDWORM

SPRAY BLOCKS

SCALE = 1" = 25 miles

The July defoliation survey indicated an increase in size and intensity of the 1972 infestation in most areas. Egg mass counts were generally higher than in 1972, and there was some evidence of an influx of moths into some 1973-sprayed areas from sources outside the spray areas.

Hazard ratings determined from data taken during the egg mass survey in particular, indicated that approximately 430,000 acres would be in need of spray application in 1974. These areas are summarized in Appendix A-6. Soaking-out of overwintering larvae is still being carried on and will update existing data.

CONDITIONS IN ADJACENT CANADIAN PROVINCES[1.]

In the Province of New Brunswick, Forest Protection Ltd. sprayed 4.2 million acres in 1973 with an emulsion of fenitrothion. Spray efficacy using Abbott's formula was 81% on fir. Foliage protection was adaquate and similar to 1972 results.

Ground observations of defoliation indicated that the amount of defoliation decreased in southern N.B. (Counties of Saint John, Albert, Westmoreland, King's, Queens and Charlotte) and generally increased in the northern counties, particularly in Madawaska Co. A total of 3.5 million acres of severe and 4.3 million acres of moderate defoliation were delineated.

Egg mass counts indicated that the infestation increased both in size and intensity. High infestations increased from 4.8 to 11.0 million acres. Lowest increases were in southern N.B. and in 1973-sprayed areas. Despite increased egg mass counts and amounts of defoliation, hazard area has decreased due to spraying and a large proportion of the infestation is in new areas. There are 3.9 million acres of extreme to high hazard for 1974.

In the Province of Quebec, 9.7 million acres were sprayed in 1973; 2.7 million in the Lac des Loups sector (oil-based Fenitrothion), 2.1 million in the LaMacaza sector (oil-based Fenitrothion or Matacil), 2.6 million in the Casey sector (oil-based Fenitrothion), 1.2 million in the Riviere-du-Loup sector (water-based Phosphamidon), and 1.2 million in the Bonadventure sector (water-based Phosphamidon). Original populations were reduced by 82.5% and foliage protection averaged 63%, with a range of 52 to 76%. Current year's defoliation was severe on 8.1 million acres and trees are dead on 325,000 acres outside the treated area.

Egg mass counts in the treated areas were slightly higher than in 1972 (520/100 sq. ft.). In Eastern Quebec egg populations were relatively low (36/100 sq. ft.). The budworm appears to be building up in the Matapedia Valley.

About 12 million acres are under consideration for spray treatment in 1974; 11.7 million in Western Quebec, and 300,000 acres in the Riviere-du-Loup sector. The latter area needs to be sprayed to prevent tree mortality.

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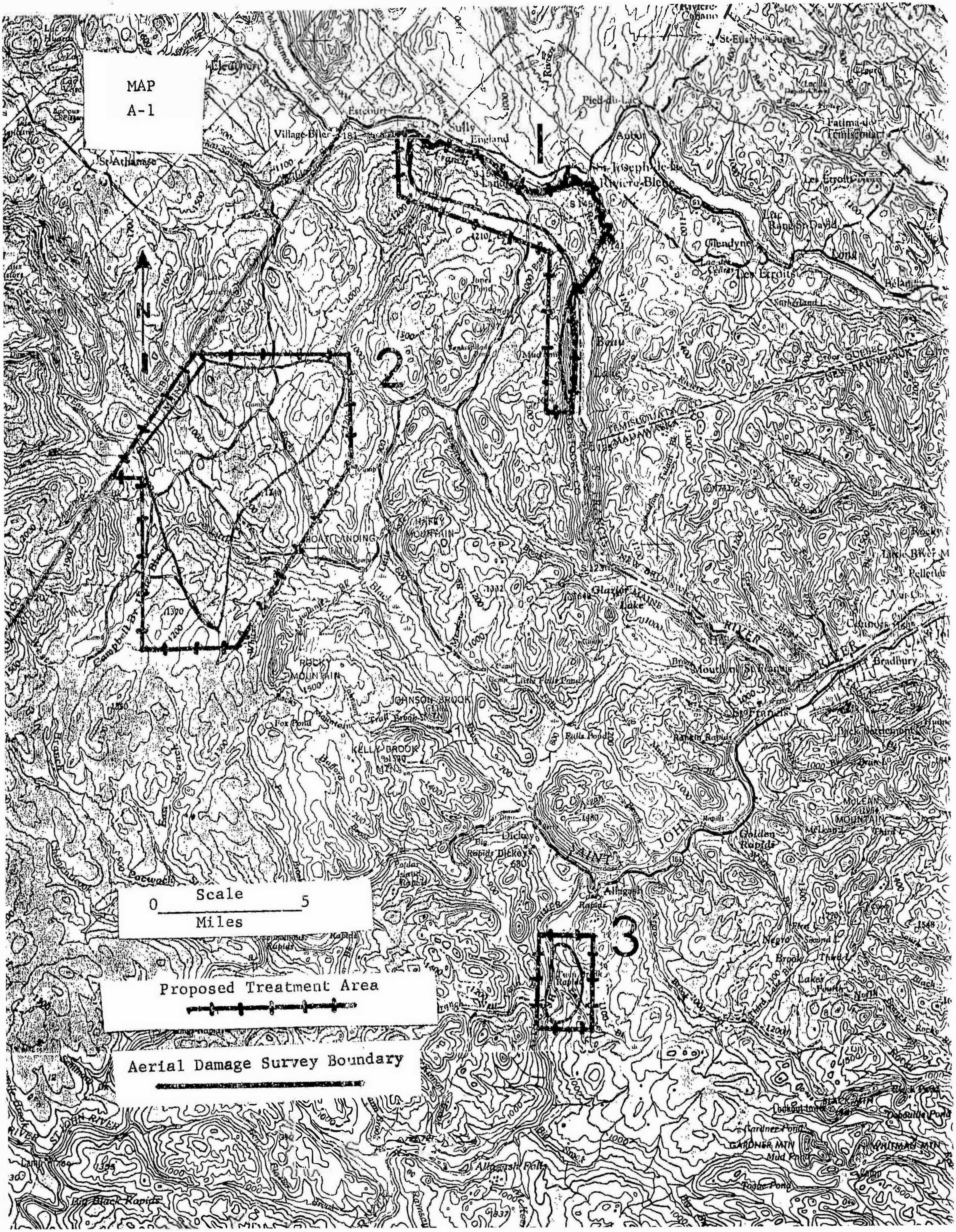
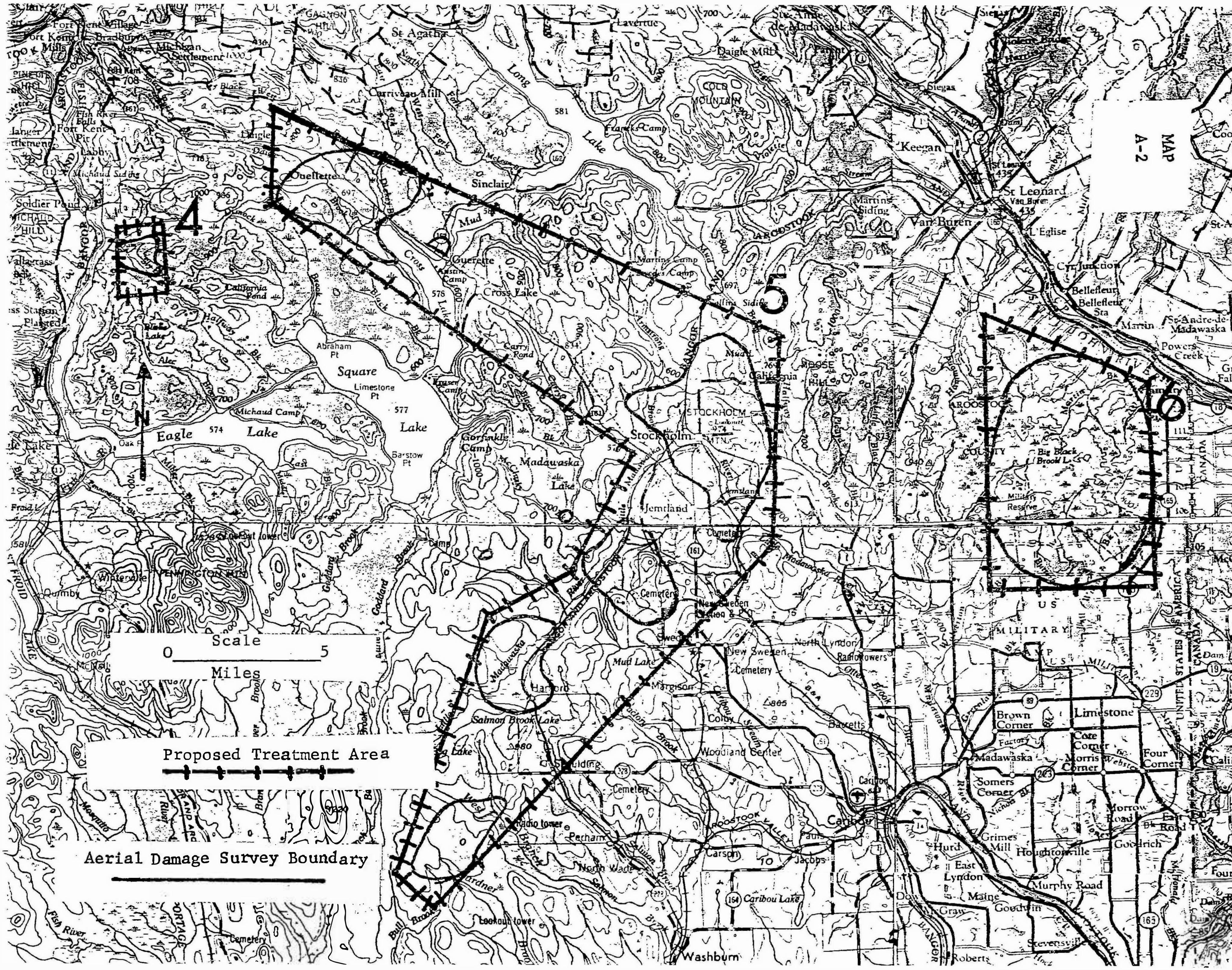
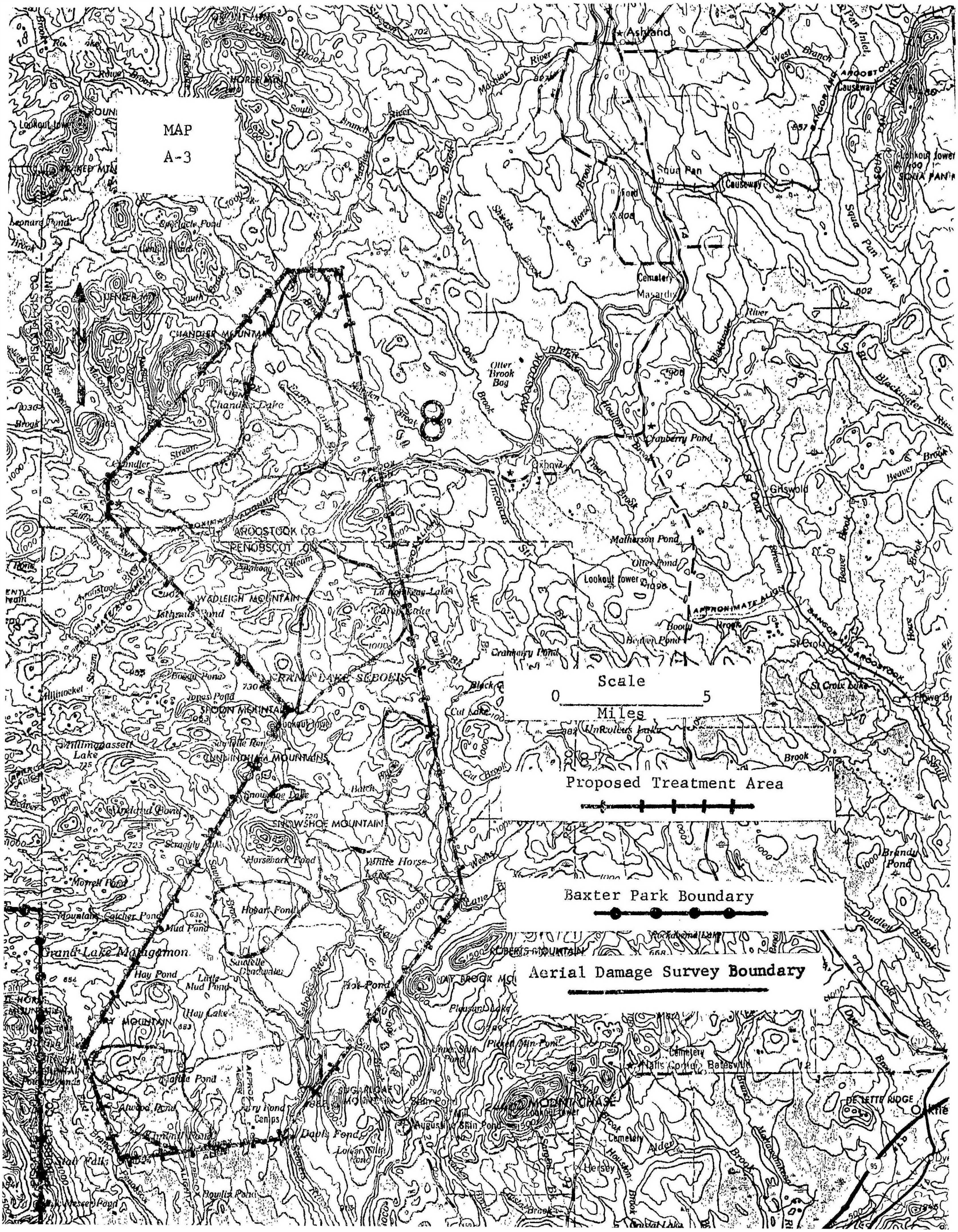
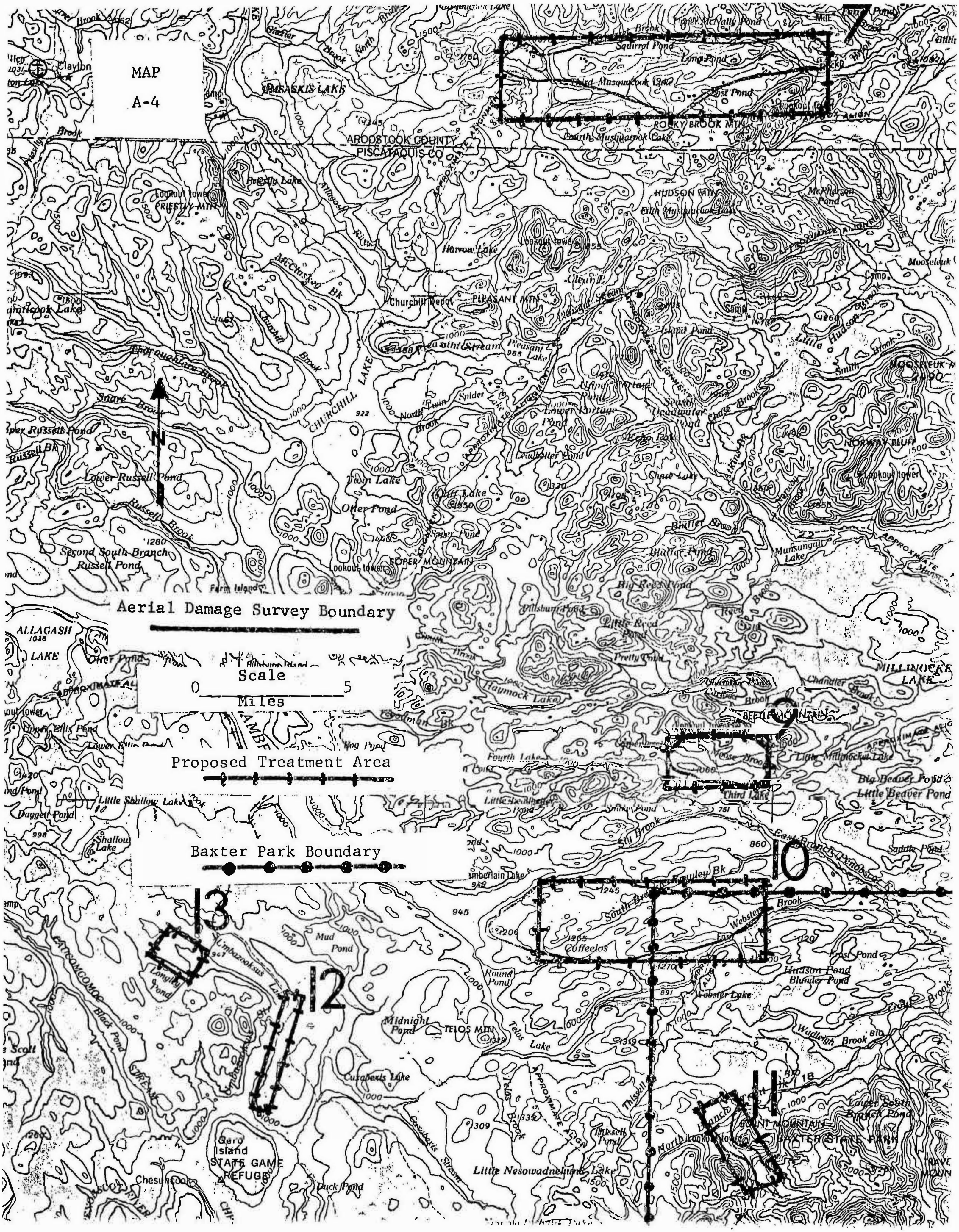
1. Summarized from Kettela, E.G. 1973. "Aerial Spraying Against the Spruce Budworm in 1973 and a Forecast of Conditions in the Maritimes Region in 1974" (Mimeo Report); and Desauliners, Real. 1973. "Summary Report on the Spruce Budworm Operations in Quebec in 1973 and Prospects for 1974." Dept. Lands & Forests, Ent. & Path. Service.

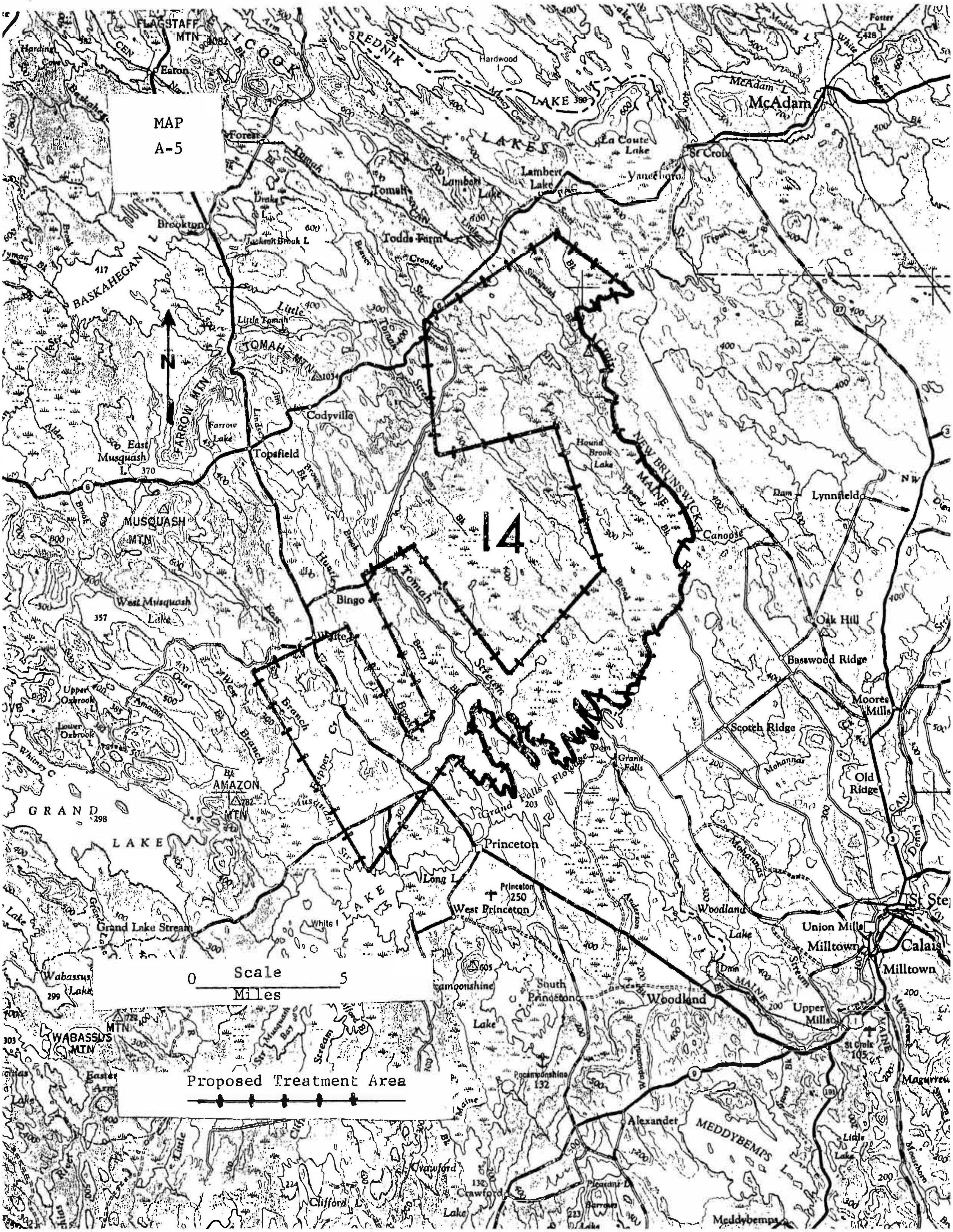
A P P E N D I X


MAP
A-1
1
2
3
N
Scale
0 5
Miles
Proposed Treatment Area
Aerial Damage Survey Boundary


MAP
A-2
Scale
0 5
Miles
Proposed Treatment Area
Aerial Damage Survey Boundary
4
5
6
N
Eagle Lake
Square Lake
Long Lake
Cross Lake
Madawaska Lake
Stockholm
Van Buren
St Leonard
Keegan
St Agatha
Sinclair
Guerette
Jemtland
New Sweden
Caribou
Washburn
Limestone
US MILITARY
AROOSTOOK COUNTY
UNITED STATES OF AMERICA
CANADA


MAP
A-3
Scale
0 5
Miles
Proposed Treatment Area
Baxter Park Boundary
Aerial Damage Survey Boundary
Ashland
Masardis
AROOSTOOK RIVER
AROOSTOOK CO.
PENOBSCOT CO.
CHANDLER MOUNTAIN
Chandler Lake
WADLEIGH MOUNTAIN
GRAND LAKE SEBOEIS
SPOON MOUNTAIN
SNOWSHOE MOUNTAIN
Grand Lake Matagamon
MOUNT CHASE
Griswold
St Croix Lake
Squa Pan Lake
Oxbow
Patten


MAP
A-4
Aerial Damage Survey Boundary
Scale
0 5
Miles
Proposed Treatment Area
Baxter Park Boundary
AROOSTOOK COUNTY
PISCATAQUIS CO
7
9
10
11
12
13
Squirrel Pond
Long Pond
ROCKY BROOK MTN
UMSASKIS LAKE
Churchill Depot
PLEASANT MTN
CHURCHILL LAKE
Lower Russell Pond
Second South Branch
Russell Pond
Twin Lake
Otter Pond
Big Reed Pond
Little Reed Pond
Haymock Lake
Fourth Lake
Third Lake
BEETLE MOUNTAIN
MILLINOCKET LAKE
Little Millinocket Lake
Big Beaver Pond
Little Beaver Pond
ALLAGASH LAKE
Little Shallow Lake
Daggett Pond
Coffeelos
Webster Lake
Hudson Pond
Frost Pond
Mud Pond
Round Pond
Midnight Pond
TELOS MTN
Telos Lake
Cuxabexis Lake
Little Nesowadnehunk Lake
BAXTER STATE PARK
Lower South Branch Pond
Gero Island
STATE GAME REFUGE
Chesuncook
Duck Pond
Longley Pond
Umbazooksus
Black Pond
Munsungan Lake
Moosehead


MAP
A-5
N
14
Scale
0
5
Miles
Proposed Treatment Area
FLAGSTAFF MTN
Eaton
SPEDNIK
LAKES
McAdam
Forest
Tomah
Lambert Lake
Vanceboro
St Croix
Brookton
BASKAHEGAN L
Todds Farm
TOMAH MTN
FARROW MTN
Codyville
Topsfield
East Musquash L
MUSQUASH MTN
West Musquash Lake
Bingo
Hound Brook Lake
NEW BRUNSWICK
MAINE
Canoose
Lynnfield
Oak Hill
Basswood Ridge
Moores Mills
Scotch Ridge
Old Ridge
Upper Oxbrook L
Lower Oxbrook L
AMAZON MTN
GRAND LAKE
Grand Falls Flowage
Grand Falls
Princeton
Long L
West Princeton
Grand Lake Stream
Wabassus Lake
WABASSUS MTN
Woodland
Union Mills
Milltown
Calais
South Princeton
Upper Mills
Alexander
MEDDYBEMPS L
Crawford
Clifford L
Meddybemps

1973 Biological Checks on Spruce Budworm Spraying
May 30 - June 5 and June 11 - 19
in Ashland, Oxbow to Smyrna Mills Area

A. E. Brower - Augusta, Maine

Outside of spray blocks 34 (operational) 35 (2 applications) and 37 (once @ 1 Qt./A) all blocks have been cut intermittantly; have much debris from cutting, sprout growth, and often heavy bush and herbaceous plant growth which made searching difficult. Some areas are mixed growth and to nearly pure hardwoods. Natural waterholes were few and recent timber cutting provided moderate to small numbers or no quiet pools. Many heavy, cloudy days made searching difficult. The break June 6 - 10 was for a shift of spray planes to remote areas and made a trip to the Augusta Laboratory for drop cloths possible. Early in the project bird migration was heavy, becoming less so later.

Insects were low in numbers and few in species May 30; they continuously increased in both numbers and species, emerging daily. Because of emergence living active insects were not included in the records. The records are based on dead or moribund specimens. Many of the frailer and longer dead specimens were too water soaked or decayed to collect, and due to their small importance not all were checked and counted.

At all times both on spray blocks and off on unsprayed areas a watch was kept on plant life: liverworts, mosses, horsetails, ferns, and all monocotyledonous and dicotyledonous plants for any sign of necrotic effects from the spraying. Time between accessible spray operations and direct checking on spray effects was spent on areas which could serve as check areas observing all life for anything dead or moribund or for necrotic plant tissue. A number of plant diseases were observed in the course of this work which required differentiation from spray injury. Two interesting plants were added to the three year list: Toothwort, *Dentaria diphylla* and Bog Birch, *Betula pumila*; the latter on the semi-floating lands on the back side of Portage Lake toward the outlet.

A continuous watch was kept for dead or moribund higher forms of life, both on and off of spray blocks. The following mammals were seen: moose, deer, hares, squirrels, woodchuck, and fresh tracks of bear, raccoon and muskrat. Several snakes were seen, also minnows.

Birds were given considerable attention, both on and off of the spray plots. Migration constantly changed the species and numbers. Additional species were added to the previous list of 71 species, making a total of 78 species observed in the spray area in three years. No visiting monitors were recruited during this project to help look for dead birds, but during a lull in the local spraying on June 16, I spent about four hours on a field trip out of Portage with the Northern Maine Chapter of the National Audubon Society, during which I discussed with several members phases of the work I was carrying on. Near the boundary between Plots 19 and 20 (operational) on June 18, I found on the bank of a logging road a dead Common Grackle. The area was fairly near farm lands near Smyrna Mills. It had been sprayed the night before. I examined the grackle and concluded it had probably been dead before the time the spray was applied or very soon after. On inquiry, I learned the federal ornithologists had left the spray project.

Pinned, labelled and a partly-named collection of insects and updated lists of other groups will be deposited in the Forestry Laboratory.

1973 Spray Blocks nos. 18, 19 and 20 (Knowles Corner, Moro east to Smyrna Mills.) Good days, Much brushy mixed growth, some near pure hardwood. Spraying completed June 17 and 18 P.M. Block 18 June 17, towards Rockabema Lake, 2-3 roads, Moro, etc.

	June 17	June 18	June 19 (Post-spray)	Total
Hymenoptera: Parasitic Hymen.	1	23		24
Black-headed Sawfly larvae		3	1	4
Carpenter ant		5		5
Diptera: Crane flies	6	58	5	69
Snipe flies	5	13	2	20
fly sp.	1	9		10
Syrphid flies	2		8	10
Tachinid flies		6	2	8
Midges (on pool under yellow birch)			350	350
Gnats	12	37	14	63
Misc. Diptera	2	408	8	418
Lepidoptera:				
Noctuidae: 1962 Prtoleucania albilinea		1 ♀		1
2533 Euplexia benesimilis		1 ♀		1
Geometridae: Cankerworm larvae		95	8	103
4680+ Semiothisa sp.	1			1
4803 Eufidonia notataria	1			1
4856 Melanolophia canadaria	1 ♀	2	2	5
4857 " signataria			1 ♀	1
5042 Anagoga pulveraria		1	1	2
5090.1 Pyrausta magniferalis			1	1
7408 Spruce budworm	2	3	6	11
8464 Semioscopis allenella		1		1
Trichoptera: Leptoceridae: Triaenodes sp.		7	1	8
Coleoptera: Hydrophilidae	2	6		8
Cantharidae	1	1		2
Melandryidae: 12552 Melandrya striata Say		1		1
Scarabaeidae: Dichelonyx		9	2	11
Cerambycidae: Evodinus monticola 14349		2		2
" sp.		1		1
" Anthophilax			1	1
Neuroptera				
Homoptera			1	1
Plecoptera		14		14
Odanata		6	2	8
Ephemeroptera	1	18	3	22
Earthworms	3	35		38

1973 Insect Knockdown Check on Zectran Spray Blocks

	Block nos. 33 & 34* June 4 Pre-spray	Block nos. 33 & 34* June 13 Post-spray	Block no. 35** June 4 Post-spray (1st Appl.)	Block no. 35** June 13 Post-spray (2nd Appl.)
Hymenoptera				Water
Argid sawfly			1	holes
Sawfly adult			1	mostly
Diprionid sawflies, small black-				dry
headed larvae	2		1	
Ichneumon parasites		1	1	
Ophion			3	
Carpenter ant, *Camponotus*	2	2	3	1
Diptera				
Crane flies	2	4	1	1
Tachinid flies	3	4	6	1
Muscid flies		1	2	
Syrphid flies		2	5	2
Black-winged flies			2	
Brilliant green	1	3	2	
Gnats	8	127	6	4
Midges	6	32	9	
Lepidoptera				
Noctuid larva	1			
Geometridae				
4223 *Nyctobia limitaria*	2	1	1	
4223.1 " *anguilineata*	2	1	2	1
Eupithecia sp. (adults)	2	1	2	1
4587 *Earophila vasiliata*	3	1	1	
5038 *Plagodis alcoolaria iris*		1		
Tortricidae				
Spruce Budworm		213	115	3
Coleoptera				
Carabidae			1	
Dytiscidae		1	1	
Hydrophilidae	1	5	1	1
Beetle larva			1	1
Staphylinidae			1	
Lycidae				
Eros aurora		1	2	
Cantharidae			1	
Elateridae				
Ludius triundulatus	1	1	2	
Byrrhidae				
Cytilus alternatus			1	
Scarabaeidae				
Dichelonyx sp.	1	2		1
Cerambycidae				
Evodinus monticola	1	2	1	
Chrysomelidae				
Syneta borealis Brown		1	1	
Orsodacne atra		1	1	
Curculionidae				
Hypomolyx piceus		1		
Hemiptera				
Gerridae: *Gerris marginatus*			2	
Anthocoridae sp. near *Tetraphleps*			1	
Plecoptera small sps.			3	2
Ephemeroptera	2		3	1

*Block # 33 & 34 sprayed operationally 6/19 and 6/11, 6/12 respectively (single appl.)

**Block #35 sprayed experimentally (2 applications) - 1st 6/3; 2nd 6/12

1973 Experimental 25 Acre Zectran (2 Applications), Plots Nos. E-2 & E-3

These two hillside plots of spruce, fir and other trees were located June 4. There were worked June 5 and June 12 after initial and second sprays were applied on 6/4 and 6/12 respectively. Most of the larger spruce and fir are spaced with considerable broad-leaved species. Areas of bushes occur and much herbaceous vegetation. The few water holes were small and poorly located, consequently I found very small numbers of the commonest insects killed by the spray, an inadequate sample. Decision to compare spray kill on the Fenitrothion plots with the regular blocks sprayed with Zectran was a wise one and not try to use Experimental plots nos. E-2 and E-3. Therefore due to the small size of the helicopter application plots, and extensive brush and general unsuitability of terrain to make meaningful observations on Zectran Blocks E-2 and E-3, no reasonable comparisons could be made regarding the relative effects on target and non-target insects between the Zectran and Fenitrothion helicopter applications. For this reason knockdown on Fenitrothion-treated blocks E-1 and E-4 was compared with knockdown on operationally-treated Zectran blocks.

1973 Experimental Fenitrothion spray plots E-1 and E-4 of 25 acres each sprayed twice, Ashland and Castle Hill, all on farm woodlots, with cutting debris, bushes, rank vegetation and near lack of water holes made any checking difficult. During a break in the local spraying a trip was made back to the Laboratory for drop cloths. These were put down in Fenitrothion plots E-1 and E-4 before spraying and worked the day following spraying and again after a one day interval. Spray was applied June 4 A.M. and June 12 A.M.

Plot no. E-1 Ashland	June 5 (Post-spray) 1st Appl.	June 12 (Post spray) 2nd Appl.	June 14 (Post-spray)	Total (Post-spray)
Hymenoptera: Black-headed Sawfly,				
young larva		2	6	8
Ichneumonidae		24+	29	53
" Ophion			1	1
Carpenter Ant		2	5	7
Diptera: Crane flies	1		11	12
Tachinid flies	1		8	9
misc. Diptera	5	8	92	105
Snipe flies			6	6
Syrphid flies			4	4
Muscid flies			9	9
Bibio sp.	1			1
Lepidoptera: Forest Tent Caterpillar				
Malacosoma Disstria			1	1
Geometridae - larvae			6	6
Canker worms	3	37	77	117
Eupithecia larvae			4	4
Tortricidae: Archips dissitanus?			2	2
" sp.? (Not Zeiraphera)			4	4
Spruce Budworm		121	127	248
Coleophoridae: Coleophora sp.?			4	4
Coleoptera: Cantharidae			2	2
Lampyridae: Lucidota corrusca			1	1
Nitidulidae: Epuraea?			1	1
Elateridae: Ludius triundulatus		2		2
Scarabaeidae: Dichelonyx			3	3
Chrysomelidae: Syneta hudsonica?			1	1
Curculionidae: Sciaphilus muricatus			1	1
Yellowish white grubs			15	15
Coccinellidae: Cleis hudsonica		2		2
Trichoptera: sps.			4	4
Neuroptera: Hemerobiidae: Kimmisia longipes		1		1
Sialidae: Sialis			2	2
Homoptera: Leaf hoppers			2	2
Plecoptera:	2	82	3	87
Ephemeroptera: Mayflies			5	5

1973 Experimental Spraying of 25 Acre Fenitrothion Plot no. E-4 in Castle Hill near the Aroostook River. Numbers for this plot are somewhat low because some of the area checked was outside of the plot.

	June 12 (Post-spray)	June 14 (Post-spray)	Total
Hymenoptera:			
Tenthredinidae: small black-headed sawfly	3	3	6
Ichneumonidae: misc. parasitic Hymen		6	6
Andrenidae: Andrenid bee	1		1
Diptera:			
Tipulidae: craneflies		3	3
Tachinidae:		2	2
Muscid flies		4	4
Gnats		5	5
Misc. flies		12	12
Lepidoptera:			
Geometridae: Cankerworm type larva	2	3	5
" *Eupithecia* larva	2	2	4
Tortricidae: green larvae		2	2
" Spruce budworm	108	75	183
Micro sp.? larva		1	1
Coleophoridae: *Coleophora* sp.(on aspen?) larval cases	21	37	58
Coleoptera:			
Carabidae: sp.		1	1
Elateridae: *Ludius triundulatus*		1	1
Staphylinidae: sp.	1		1
Plecoptera:		4	4
Ephemeroptera		3	3

The 1973 Spray Block no. 27 (Zectran, operational), four circuits June 14. Dark clouds, moderately good water holes. Located June 2 with federal group. Sprayed June 14 A.M. E. 1/2: June 18 W. 1/2; worked late P.M.

	June 14
Hymenoptera: Carpenter Ant	1
Diptera: Crane flies	10
Misc. flies	3
Snipe flies	1
Tachinid flies	1
Gnats	6
Lepidoptera: Spruce Budworm	43
Plecoptera: Stone flies	2

Spray Block no. 37 (Zectran once @ 1 qt./A); Sprayed June 14 A.M.; worked June 15, 1974 with R. L. Marsalis. After rain, low clouds, few water holes.

	June 15
Hymenoptera: Parasitic Hymen	3
Carpenter Ant	1
Diptera: Crane flies	9
Misc. flies	5
Gnats	8
Snipe flies	2
Lepidoptera: Spruce Budworm larvae	17
Trichoptera	1
Mecoptera	1
Coleoptera: *Dichelonyx* sp.	1
Plecoptera: Stoneflies	33
Ephemeroptera: Mayflies	1